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(54) IMAGE PICKUP LENS DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an image pickup lens device, having a high variable power zoom lens system which has variable power ratio of about 7-10 and F-number of about 2.5-4, has excellent performance capable of being used as an optical system for a newest imaging device whose picture element pitch is small and has

excellent compactness property.

SOLUTION: This zoom lens system comprises a first lens group (Gr1) of positive power, a second lens group (Gr2) of negative power, a third lens group (Gr3) of positive power and a fourth lens group (Gr4) of negative power in this order from an object side, and the conditional expression $1.1<f1/fT<2.5$, where f1 is the focal distance of the first lens group (Gr1) and fT is the focal distance of the entire system at a telephoto end (T) is satisfied.

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2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] The zoom lens system which performs variable power by consisting of two or more lens groups, and changing lens group spacing, The image sensor which changes into an electric signal the optical image formed of the zoom lens system, The 1st lens group in which it is preparation ****** lens equipment and said zoom lens system has forward power in order [side / body], Image pick-up lens equipment characterized by satisfying the following conditional expression (1) including the 2nd lens group which has negative power, the 3rd lens group which has forward power, and the 4th lens group which has negative power;

$1.1<f1/fT<2.5$ -- the focal distance of the (1), however f1:1st lens group, and the focal distance of the whole system in fT:tele edge -- it comes out.

[Claim 2] Image pick-up lens equipment according to claim 1 characterized by performing focusing and satisfying the following conditional expression (2) further when said 4th lens group moves in the direction of an optical axis;

0.3<|f4/fT|<2 -- (2), however the focal distance of the f4:4th lens group -- it comes out.

[Claim 3] Image pick-up lens equipment according to claim 1 or 2 with which said 1st lens group moves and spacing of said 3rd lens group and said 4th lens group is characterized by for a wide angle edge to a middle focal distance increasing, and a middle focal distance to a tele edge decreasing in zooming from a wide angle edge to a tele edge.

[Claim 4] The zoom lens system which performs variable power by consisting of two or more lens groups, and changing lens group spacing, The image sensor which changes into an electric signal the optical image formed of the zoom lens system, The 1st lens group in which it is preparation ****** lens equipment and said zoom lens system has forward power in order [side / body], Image pick-up lens equipment characterized by for the 1st lens group moving in zooming and satisfying the following conditional expression (3) including the 2nd lens group which has negative power, the 3rd lens group which has forward power, and the 4th lens group which has negative power;

0.3 -- < -- D34 W/D34T<2.5 -- (3) however air spacing between the 3rd lens groups and the 4th lens groups in a D34W:wide angle edge, and air spacing

between the 3rd lens groups and the 4th lens groups in a D34T:tele edge -- it comes out.

[Claim 5] Image pick-up lens equipment according to claim 4 characterized by said 4th lens group moving to a body side in zooming from a wide angle edge to a tele edge.

[Claim 6] Image pick-up lens equipment according to claim 4 or 5 with which spacing of said 3rd lens group and said 4th lens group is characterized by for a wide angle edge to a middle focal distance increasing, and a middle focal distance to a tele edge decreasing in zooming from a wide angle edge to a tele edge.

[Claim 7] Image pick-up lens equipment according to claim 4, 5, or 6 characterized by for focusing being performed by migration of said 4th lens group, and satisfying the following conditional expression (4) further;

0.5< betaW4<2 -- the lateral magnification of the 4th lens group in a (4), however betaW4:wide angle edge -- it comes out.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] the image pick-up lens equipment to which this invention is optically incorporated according to optical system, and outputs especially the image of a photographic subject as an electric signal with an image sensor about image pick-up lens equipment -- {-- for example, it is related with the image pick-up lens equipment which equipped a digital camera; video camera; digital video unit, the personal computer, the mobile computer, the cellular phone, the information personal digital assistant (PDA:Personal Digital Assistant), etc. with built-in or main component} of the camera by which external is carried out, and the zoom lens system of high variable power compact especially.

[0002]

[Description of the Prior Art] the 1st lens group which has forward power in order [side / body] as a high variable power zoom lens for digital cameras, the 2nd lens group which has negative power, the 3rd lens group which has forward power, and the 4th lens group which has forward power -- since -- the type which changes occupies the mainstream conventionally (for example, JP,4-296809,A). This is because forward, negative, forward, and a forward type are excellent in compactability.

[0003] moreover, as a zoom lens which attained the high variable power ratio The 1st lens group which has forward power in order [side / body], and the 2nd lens group which has negative power, The 3rd lens group which has forward power, and the 4th lens group which has negative power, since -- with the 1st lens group which has forward power in order [side / the what (for example, JP,5-341189,A) side changes, and / body] the 2nd lens group which has negative power, the 3rd lens group which has forward power, the 4th lens group which has negative power, and the 5th lens group which has forward power -- since -- what changes (for example, JP,10-111457,A) is known.

[0004]

[Problem(s) to be Solved by the Invention] Since the 1st lens group is immobilization in zooming, the zoom lens of forward, negative, forward, and the negative type proposed by JP,5-341189,A is unsuitable for further high-performance-izing accompanying the further formation of a high variable power ratio and the further formation of a small pitch of an image sensor. Moreover, although the zoom lens of forward, negative, forward, negative, and the forward type proposed by JP,10-111457,A also moves the 1st lens group in zooming, especially many aberration generated by each group since the power of the 1st and 2nd lens group is strong becomes large. Therefore, it is difficult to realize further high performance-ization accompanying the further formation of a high variable power ratio and the further formation of a small pitch of an image sensor. Moreover, the type containing forward, negative, forward, and the negative one to which the 4th lens group changes from a negative group also has the fault that it is a little inferior by compactability compared with forward and a negative, forward, and forward type.

[0005] This invention is made in view of such a situation. The purpose It is in realizing a type with the performance which exceeds forward, negative, forward, and a forward type by compactability. 7 times to about 10 times and the f number

especially about by 2.5 to four [a variable power ratio] It aims at offering the image pick-up lens equipment which has the high variable power zoom lens system which had the high engine performance which can be used also as optical system for the image sensors of the latest small pixel pitch, and was excellent in compactability.

[0006]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the image pick-up lens equipment of the 1st invention The zoom lens system which performs variable power by consisting of two or more lens groups, and changing lens group spacing, The image sensor which changes into an electric signal the optical image formed of the zoom lens system, The 1st lens group in which it is preparation ****** lens equipment and said zoom lens system has forward power in order [side / body], It is characterized by satisfying the following conditional expression (1) including the 2nd lens group which has negative power, the 3rd lens group which has forward power, and the 4th lens group which has negative power.

$1.1<f1/fT<2.5$ -- the focal distance of the (1), however f1:1st lens group, and the focal distance of the whole system in fT:tele edge -- it comes out.

[0007] In the configuration of invention of the above 1st, focusing is performed and the image pick-up lens equipment of the 2nd invention is characterized by satisfying the following conditional expression (2) further, when said 4th lens group moves in the direction of an optical axis.

$0.3<|f4/fT|<2$ -- (2), however the focal distance of the f4:4th lens group -- it comes out.

[0008] The image pick-up lens equipment of the 3rd invention is characterized by for said 1st lens group moving, for spacing of said 3rd lens group and said 4th lens group increasing from a wide angle edge to a middle focal distance, and a middle focal distance to a tele edge decreasing in zooming from a wide angle edge to a tele edge in the configuration of the above 1st or the 2nd invention.

[0009] The zoom lens system which performs variable power by the image pick-up lens equipment of the 4th invention consisting of two or more lens groups, and changing lens group spacing, The image sensor which changes into an electric signal the optical image formed of the zoom lens system, The 1st lens group in which it is preparation ****** lens equipment and said zoom lens system has forward power in order [side / body], Including the 2nd lens group which has negative power, the 3rd lens group which has forward power, and the 4th

lens group which has negative power, the 1st lens group moves in zooming and it is characterized by satisfying the following conditional expression (3).

0.3 -- < -- D34 W/D34T<2.5 -- (3) however air spacing between the 3rd lens groups and the 4th lens groups in a D34W:wide angle edge, and air spacing between the 3rd lens groups and the 4th lens groups in a D34T:tele edge -- it comes out.

[0010] The image pick-up lens equipment of the 5th invention is characterized by said 4th lens group moving to a body side in zooming from a wide angle edge to a tele edge in the configuration of invention of the above 4th.

[0011] The image pick-up lens equipment of the 6th invention is characterized by for spacing of said 3rd lens group and said 4th lens group increasing from a wide angle edge to a middle focal distance, and a middle focal distance to a tele edge decreasing in zooming from a wide angle edge to a tele edge in the configuration of the above 4th or the 5th invention.

[0012] In the configuration of the above 4th, the 5th, or the 6th invention, focusing is performed by migration of said 4th lens group, and the image pick-up lens equipment of the 7th invention is characterized by satisfying the following conditional expression (4) further.

0.5< betaW4<2 -- the lateral magnification of the 4th lens group in a (4), however betaW4:wide angle edge -- it comes out.

[0013]

[Embodiment of the Invention] Hereafter, the image pick-up lens equipment which carried out this invention is explained, referring to a drawing. the camera with which the image pick-up lens equipment which incorporates the image of a photographic subject optically and is outputted as an electric signal is used for still picture photography and animation photography of a photographic subject -- {-- for example, it is the main component of built-in or camera} by which external is carried out at a digital camera; video camera; digital video unit, a personal computer, a mobile computer, a cellular phone, an information personal digital assistant (PDA), etc. as shown in drawing 26 , the image pick-up lens equipment comes out sequentially from a body (photographic subject) side with the image sensor (SR) which changes into an electric signal the optical image formed of the taking-lens system (TL) which forms an objective optical image, and the plane-parallel plate (PL) equivalent to an optical low pass filter etc. and a taking-lens system (TL), and is constituted.

[0014] With the gestalt of each operation mentioned later, the zoom lens system

which consists of two or more lens groups is used as a taking-lens system (TL), two or more lens groups move in accordance with an optical axis (AX), and variable power is performed by changing lens group spacing. Solid state image sensors which consist, for example of two or more pixels as an image sensor (SR), such as CCD (Charge Coupled Device) and a CMOS (Complementary Metal Oxide Semiconductor) sensor, are used, and the optical image formed of the zoom lens system is changed into an electric signal. Moreover, when the optical image which should be formed by the zoom lens system passes the optical low pass filter (PL) which has the predetermined cut-off frequency property determined with the pixel pitch of an image sensor (SR), spatial frequency characteristics are adjusted so that the so-called clinch noise generated in case it is changed into an electric signal may be minimized. Predetermined digital image processing, picture compression processing, etc. are performed if needed, it is recorded on memory (semiconductor memory, optical disk, etc.) as a digital video signal, a cable is minded depending on the case, or the signal generated with the image sensor (SR) is changed into an infrared signal, and is transmitted to other devices.

[0015] Drawing 1 - drawing 9 are the lens block diagrams corresponding to the

zoom lens system which constitutes the gestalt of the 1st - the 9th operation, respectively, and show lens arrangement in a wide angle edge (W) in the optical cross section. The arrow head mj (j= 1, 2, ...) in each lens block diagram shows typically migration (however, the broken-line arrow head mj expresses that it is location immobilization in zooming.) of the j-th lens group (Grj) in zooming from a wide angle edge (W) to a tele edge (T), respectively, and the arrow head mF shows the migration direction of the focal group in focusing to the contiguity from infinite distance. Moreover, among each lens block diagram, the field where ri (i= 1, 2 and 3, ...) was attached is counted from a body (photographic subject) side, and is the i-th field, and the field where * mark was given to ri is the aspheric surface. Axial top-face spacing to which di (i= 1, 2 and 3, ...) was given is variable spacing which counts from a body side and changes in zooming among the i-th axial top-face spacing.

[0016] Each zoom lens system of the gestalt of each operation contains the 1st lens group (Gr1) which has forward power, the 2nd lens group (Gr2) which has negative power, the 3rd lens group (Gr3) which has forward power, and the 4th lens group (Gr4) which has negative power in order [side / body]. And the glass plane-parallel plate equivalent to an optical low pass filter etc., i.e., a glass plate,

(PL) is arranged at the image surface side as a zoom lens system used for the camera (for example, digital camera) equipped with the solid state image sensor (for example, CCD). Also in the gestalt of which operation, a glass plate (PL) is location immobilization in zooming, and the 3rd lens group (Gr3) is extracted to the maximum body side, and contains (ST).

[0017] the 1st lens group (Gr1) in which the zoom lens system of the gestalt of the 1st operation has forward power in order [side / body], the 2nd lens group (Gr2) which has negative power, the 3rd lens group (Gr3) which has forward power, and the 4th lens group (Gr4) which has negative power -- since -- it is 4 group zoom lens of forward, negative, forward, and the negative type which changes. The zoom lens system of the gestalt of the 2nd - the 4th, 6th, 8th, and 9th operation The 1st lens group (Gr1) which has forward power in order [side / body], and the 2nd lens group which has negative power (Gr2), the 3rd lens group (Gr3) which has forward power, the 4th lens group (Gr4) which has negative power, and the 5th lens group (Gr5) which has forward power -- since -- it is 5 group zoom lens of forward, negative, forward, negative, and the forward type which changes.

[0018] The 1st lens group in which the zoom lens system of the gestalt of the 5th

operation has forward power in order [side / body] (Gr1), The 2nd lens group (Gr2) which has negative power, and the 3rd lens group which has forward power (Gr3), the 4th lens group (Gr4) which has negative power, the 5th lens group (Gr5) which has forward power, and the 6th lens group (Gr6) which has negative power -- since -- it is 6 group zoom lens of forward, negative, forward, negative, forward, and the negative type which changes. The 1st lens group in which the zoom lens system of the gestalt of the 7th operation has forward power in order [side / body] (Gr1), The 2nd lens group (Gr2) which has negative power, and the 3rd lens group which has forward power (Gr3), the 4th lens group (Gr4) which has negative power, the 5th lens group (Gr5) which has forward power, and the 6th lens group (Gr6) which has forward power -- since -- it is 6 group zoom lens of forward, negative, forward, negative, forward, and the forward type which changes.

[0019] Any gestalt of operation is the zoom type which starts in forward, negative, forward, and a negative one. Compared with forward, negative, forward, and the forward type both whose 3rd and 4th lens groups (Gr3, Gr4) have forward power By the zoom type containing forward, negative, forward, and the negative one which made the 4th lens group (Gr4) the negative lens group Since the sign of

the power of the 3rd lens group (Gr3) and the 4th lens group (Gr4) is different, a higher variable power ratio can be earned by the 3rd and 4th lens group (Gr3, Gr4), and there is a merit of being easy to secure high variable power. in addition, as a type containing forward, negative, forward, and a negative one (Forward, negative, forward, and negative) 4 group type; (Forward, negative, forward, and negative) Variations, such as - forward (forward, negative, forward, and negative), negative 5 group type; (forward, negative, forward, and negative), forward [negative], and forward one, - (forward, negative, forward, and negative) forward and a negative one, a - (forward, negative, forward, and negative) negative, and 6 group type forward (forward, negative, forward, and negative), negative, and negative, are mentioned.

[0020] In the zoom lens system of the type which contains forward and a negative, forward, and negative zoom group in order, it is more desirable than a body side like the gestalt of each operation to satisfy the following conditional expression (1). Thereby, the compact zoom lens system of high variable power is realizable. And the high engine performance which a variable power ratio can use by 7 times to about 10 times, and the f number can use about by 2.5 to four also as optical system for the image sensors (SR) of the latest small pixel pitch

can be obtained.

1.1<f1/fT<2.5 -- the focal distance of the (1), however f1:1st lens group (Gr1), and fT: -- the focal distance of the whole system in a tele edge (T) -- it comes out.

[0021] If the minimum of conditional expression (1) is exceeded, the power of the 1st lens group (Gr1) will become strong too much, and it will become difficult to remove the spherical aberration especially in a tele edge (T). Moreover, if the upper limit of conditional expression (1) is exceeded, the power of the 1st lens group (Gr1) will become weak too much, and it will become difficult to secure especially the compactability in a tele edge (T).

[0022] When the 4th lens group (Gr4) moves in the direction of an optical axis (AX) in the zoom lens system of the type which contains forward and a negative, forward, and negative zoom group in order from a body side like the gestalt of each operation, it is desirable for focusing to be performed and to satisfy the following conditional expression (2) further. The zoom lens system which secured the higher engine performance is realizable with this. Moreover, it is still more desirable to satisfy conditional expression (2) with said conditional expression (1).

0.3<|f4/fT|<2 -- (2), however the focal distance of the f4:4th lens group (Gr4) -- it

comes out.

[0023] As shown in conditional expression (2), the power of the 4th lens group (Gr4) is comparatively weak, therefore lens number of sheets also has few 4th lens groups (Gr4). It is optimal that migration (mF) of the direction of an optical axis (AX) of the 4th lens group with small lens weight (Gr4) performs focusing from this. However, when the system in which focusing in an image sensor (SR) is possible can be adopted, even if migration of an image sensor (SR) is made to perform focusing, it does not interfere.

[0024] If the minimum of conditional expression (2) is exceeded, the power of the 4th lens group (Gr4) will become strong too much, and it will become difficult to remove the performance degradation at the time of the contiguity especially in a tele edge (T). Moreover, if the upper limit of conditional expression (2) is exceeded, the power of the 4th lens group (Gr4) will become weak too much, the lens movement magnitude of the 4th lens group at the time of a focus (Gr4) will become large too much, and a result by which the compactability of the whole camera cone is spoiled will be brought.

[0025] Moreover, it sets like the gestalt of each operation to zooming from a wide angle edge (W) to a tele edge (T). It is desirable for the 1st lens group (Gr1) to

move, for spacing of the 3rd lens group (Gr3) and the 4th lens group (Gr4) to increase from a wide angle edge (W) to a middle focal distance, and for a middle focal distance to a tele edge (T) to decrease. The zoom lens system of high variable power is realizable with this. Moreover, it is still more desirable to satisfy conditional expression (1) and conditional expression (2) in this characteristic zoom configuration.

[0026] The type with which the 1st lens group (Gr1) is being fixed in zooming as optical system conventionally used for the video camera or the digital camera from the balance of the compactability searched for as the whole product and the difficulty of a camera cone configuration was in use. However, since it is in the situation that the further party KUTONESU and high variable power are called for, from now on, it is desirable to make the 1st lens group (Gr1) movable in zooming. Each beam-of-light height which carries out incidence to the 2nd lens group (Gr2) in a tele edge (T) can be made small, and it becomes easy to perform amendment of many aberration by moving the 1st lens group (Gr1) from a wide angle edge (W) to a body side in zooming to a tele edge (T). Moreover, in zooming from a wide angle edge (W) to a tele edge (T), when spacing of the 3rd and 4th lens group (Gr3, Gr4) considers as the configuration in which a wide

angle edge (W) to a middle focal distance increases, and a middle focal distance to a tele edge (T) decreases, it becomes possible to amend the curvature of field in a middle focal distance field good, and the zoom lens system of high variable power can be realized as a result.

[0027] Moreover, like the gestalt of each operation, it is desirable to arrange the aspheric surface in the 2nd lens group (Gr2), and the zoom lens system which starts in a wide angle more is obtained by establishing the aspheric surface at the 2nd lens group (Gr2). If the focal distance of a wide angle edge (W) tends to be made smaller and it is going to enlarge a photography field angle, distortion amendment in a wide angle edge (W) will become difficult especially. In order to remove this fault, it is desirable to arrange the aspheric surface in the comparatively high 2nd lens group (Gr2) of the beam-of-light height besides the shaft by the side of a wide angle, and it can amend distortion aberration good by this. Therefore, it is still more desirable to arrange the aspheric surface in the 2nd lens group (Gr2), while filling conditional expression (1) and conditional expression (2), when obtaining high optical-character ability, holding compactability.

[0028] If it is in the zoom lens system which the 1st lens group (Gr1) moves to

order in zooming including forward and a negative, forward, and negative zoom group from a body side like the gestalt of each operation, it is desirable to satisfy the following conditional expression (3). Thereby, the compact zoom lens system of high variable power is realizable. And the high engine performance which a variable power ratio can use by 7 times to about 10 times, and the f number can use about by 2.5 to four also as optical system for the image sensors (SR) of the latest small pixel pitch can be obtained.

0.3 -- < -- D34 W/D34T<2.5 -- (3) however air spacing between the 3rd lens groups (Gr3) and the 4th lens groups (Gr4) in a D34W:wide angle edge (W), and D34T: -- air spacing between the 3rd lens groups (Gr3) and the 4th lens groups (Gr4) in a tele edge (T) -- it comes out.

[0029] If the minimum of conditional expression (3) is exceeded, air spacing between the 3rd lens groups (Gr3) and the 4th lens groups (Gr4) in a tele edge (T) will become large too much, and it will become difficult to secure the compactability in a tele edge (T). Moreover, if the upper limit of conditional expression (3) is exceeded, air spacing between the 3rd lens groups (Gr3) and the 4th lens groups (Gr4) in a wide angle edge (W) will become large too much, and it will become difficult to secure the compactability in a wide angle edge (W).

[0030] It is desirable the 1st lens group (Gr1) not only to move, but for the 4th lens group (Gr4) to move to a body side in zooming from a wide angle edge (W) to a tele edge (T) in zooming, as mentioned above in the zoom lens system which contains forward and a negative, forward, and negative zoom group in order from the body side like the gestalt of each operation. By this, many variable power ratios in the 4th lens group (Gr4) can be earned, and a zoom lens system with a higher variable power ratio can be realized. Moreover, when balancing compactability, it is still more desirable to make it fill conditional expression (3).

[0031] Moreover, it sets in the zoom lens system which contains forward and a negative, forward, and negative zoom group in order [side / body] like the gestalt of each operation. As mentioned above, it sets to zooming from a wide angle edge (W) to a tele edge (T). Although it is desirable for spacing of the 3rd lens group (Gr3) and the 4th lens group (Gr4) to increase from a wide angle edge (W) to a middle focal distance, and for a middle focal distance to a tele edge (T) to decrease, it is still more desirable when it secures compactability that it is satisfied with this and coincidence of conditional expression (3). Thus, by carrying out zoom migration of the 3rd and 4th lens group (Gr3, Gr4), the

curvature of field of the undershirt generated especially in a middle focal distance field can be amended good, and the zoom lens system which maintained the high engine performance can be realized.

[0032] Moreover, it is desirable for focusing to be performed by migration of the 4th lens group (Gr4) as mentioned above in the zoom lens system of the type which contains forward and a negative, forward, and negative zoom group in order from the body side like the gestalt of each operation, and to satisfy the following conditional expression (4) further. A zoom lens system with the better engine performance is realizable with this. Moreover, it is still more desirable to satisfy conditional expression (4) with said conditional expression (3).

0.5< betaW4<2 -- the lateral magnification of the 4th lens group (Gr4) in a (4), however betaW4:wide angle edge (W) -- it comes out.

[0033] As mentioned above, the power of the 4th lens group (Gr4) is comparatively weak, therefore lens number of sheets also has few 4th lens groups (Gr4). The 4th lens group with lens weight small as a focal group from this (Gr4) is the optimal. However, when the system in which focusing using an image sensor (SR) is possible can be adopted, even if an image sensor (SR) is made to perform focusing, it does not interfere.

[0034] If the minimum of conditional expression (4) is exceeded, the rate of variable power shared with the 4th lens group (Gr4) in a wide angle edge (W) will become small, and the need of adding a burden to the 3rd lens group (Gr3) will come out. For this reason, removal of many aberration within the 3rd lens group (Gr3) becomes difficult as a result. When the upper limit of conditional expression (4) is exceeded, the burden of the variable power in the 4th lens group (Gr4) becomes large too much, and removal of many aberration within the 4th lens group (Gr4) becomes difficult, consequently it becomes impossible moreover, to realize a compact zoom lens system.

[0035] If the aspheric surface is arranged in the 2nd lens group (Gr2) as mentioned above, the zoom lens system which starts in a wide angle more will be obtained. If the focal distance of a wide angle edge (W) tends to be made smaller and it is going to enlarge a photography field angle, distortion amendment in a wide angle edge (W) will become difficult especially. In order to remove this fault, it is desirable to arrange the aspheric surface in the comparatively high 2nd lens group (Gr2) of the beam-of-light height besides the shaft by the side of a wide angle, and it can amend distortion aberration good by this. Therefore, it is still more desirable to arrange the aspheric surface in the

2nd lens group (Gr2), while filling conditional expression (3) and conditional expression (4), when obtaining high optical-character ability, holding compactability.

[0036] In addition, although each lens group which constitutes the gestalt of the 1st - the 9th operation consists of only refraction mold lenses (that is, lens of the type with which a deviation is performed by the interface of the media which have a different refractive index) which deflect an incident ray by refraction, it is not restricted to this. For example, each lens group may consist of a diffraction mold lens which deflects an incident ray by diffraction, a refraction / diffraction hybrid mold lens which deflects an incident ray in the combination of a diffraction operation and a refraction operation, a gradient index lens which deflects an incident ray according to the refractive-index distribution in a medium.

[0037] Moreover, in the gestalt of each operation, a rear stirrup may bend an optical path on the way before a zoom lens system by arranging the field (for example, a reflector, a refracting interface, a diffraction side) which does not have optical power in an optical path. It is [that what is necessary is just to set up a bending location if needed] possible to attain thin shape-ization on the appearance of a camera by proper bending of an optical path. Moreover, it is

also possible to make it the configuration from which the thickness of a camera changes neither with zooming nor collapsing. For example, if the 1st lens group (Gr1) is considered as location immobilization at the time of variable power, a mirror is arranged behind the 1st lens group (Gr1) and 90 degrees of optical paths are bent in the reflector, since the die length of the cross direction of a zoom lens system will become fixed, thin shape-ization of a camera can be attained.

[0038] Furthermore, with the gestalt of each operation, although the example of a configuration of the optical low pass filter of the configuration of the plane-parallel plate (PL) arrange between the last side of a zoom lens system and an image sensor (SR) be showed, as this low pass filter, a birefringence mold low pass filter made from Xtal with which the predetermined crystal orientation be adjusted, the phase mold low pass filter which attain the property of optical cut-off frequency need according to the diffraction effect be applicable.

[0039]

[Example] Construction data, an aberration Fig., etc. are mentioned and the configuration of the zoom lens system hereafter used for the image pick-up lens equipment which carried out this invention etc. is explained still more concretely.

The examples 1-9 given as an example here are equivalent to the gestalt of the 1st - the 9th operation mentioned above, respectively, and the lens block diagram (drawing 1 - drawing 9) showing the gestalt of the 1st - the 9th operation shows the lens configuration of the corresponding examples 1-9, respectively.

[0040] In the construction data of each example, ri (i= 1, 2 and 3, ...) is counted from a body side. The radius of curvature of the i-th field (mm), Count di (i= 1, 2 and 3, ...) from a body side, and the i-th axial top-face spacing (mm) is shown. nickel (i= 1, 2 and 3, ...) and nui (i= 1, 2 and 3, ...) are counted from a body side, and show the refractive index (Nd) and the Abbe number (nud) to d line of the i-th optical element. Moreover, axial top-face spacing which changes in zooming is adjustable air spacing in a wide angle edge (a short focus distance edge, W) middle (a middle focal distance condition, M) - a tele edge (a long focal distance edge, T) among construction data. The focal distance (f, mm) and the f number (FNO) of the whole system corresponding to each focal distance condition (W), (M), and (T) are combined with other data, and are shown, and the movement magnitude (focal data) of the 4th lens group (Gr4) in focusing at the time of contiguity (photography distance: D= 0.5m) is shown in Table 1, and the value

corresponding to conditional expression is shown in Table 2.

[0041] It shall be shown that the field where * mark was given to radius of curvature ri is a field which consisted of the aspheric surfaces, and it shall define as the formula (AS) of the following showing the field configuration of the aspheric surface. The aspheric surface data of each example are combined with other data, and are shown.

X(H) =(C0, H2)/{1+root (1-epsilon-C 02, H2)} + (A4, H4+A6, H6+A8 and H8+A10, H10) (AS) --AS Correct. the variation rate of the direction of an optical axis in the inside of a formula (AS), and the location of X(H):height H -- an amount (plane peak point criteria) and H : an optical axis -- receiving -- the height of a perpendicular direction, and C0 : Paraxial curvature (= 1-/radius of curvature) and epsilon : A secondary curved-surface parameter and Ai : the i-th aspheric surface multiplier -- it comes out.

[0042] Drawing 10 - drawing 25 are the aberration Figs. of an example 1 - an example 9, and the aberration Fig. in the infinite distance photography condition of an example 1 - an example 9, drawing 19 - drawing 25 of drawing 10 - drawing 18 are the aberration Figs. in examples 1-5 and the contiguity photography condition (photography distance: D= 0.5m) of 8 and 9. (W) is

astigmatism and distortion aberration, such as spherical aberration, among drawing 10 - drawing 25 sequentially from the many aberration {left [in / a wide angle edge and (M), and / in (T) / a tele edge]. [middle] Y': Maximum image quantity (mm)} is shown. In the spherical-aberration Fig., spherical aberration [as opposed to d line in a continuous line (d)], spherical aberration [as opposed to g line in an alternate long and short dash line (g)], and a broken line (SC) express sine condition. In the astigmatism Fig., the astigmatism over d line in a meridional side is expressed, and, as for the broken line (DM), the continuous line (DS) expresses the astigmatism over d line in a sagittal side. Moreover, in the distortion aberration Fig., the continuous line expresses distortion % to d line.

[0043]

<<example 1>>

f= 7.5 to 25.5 to 50.6, and FNO=2.55-2.96-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 63.832 d1= 1.200 N 1= 1.74000 nu1= 28.26r2= 46.105 d2= 4.909 N 2= 1.49310 nu2= 83.58r3= 557.712 d3= 0.100r4= 41.139 d4= 3.518 N 3= 1.49310 nu3= 83.58r5= 95.433 d5= 1.000-28.553-40.964r6= 28.766 d6= 0.800 N 4= 1.80420 nu4= 46.50r7= 8.145 d7= 6.254r8= -24.683 d8= 0.800 N 5= 1.80741 nu5= 31.59r9=408.759

d9= 2.972 N 6= 1.84666 nu6= 23.82r10= -15.616d10= 0.727r11=-12.222d11= 0.800 N 7= 1.52510 nu7= 56.38r12*=-72.536 d12=24.622-4.490-1.000r13= infinity (ST) d13= 0.800r14= 11.863d14= 2.033 N 8= 1.78831 nu8= 47.32r15= 212.313 d15= 5.251r16= -66.079 d16= 1.795 N 9= 1.48749 nu9= 70.44r17= -10.997 d17= 0.800 N 10= 1.84666 nu10=23.82r18*= 29.156 d18= 0.100r19= 12.934 d19= 3.092 N 11= 1.48749 nu11=70.44r20*=-19.433 d20= 0.100r21=-788.619 d21= 4.662 N 12= 1.79850 nu12=22.60r22= -27.115d22= 1.000-7.000 - 1.000r23= 23.066 d23= 0.800 N 13= 1.85000 nu13=40.04r24= 11.361 d24= 3.500r25=11.740 d25= 1.826 N 14= 1.79850 nu14=22.60r26= 14.538 d26= 2.381-2.000 - 13.578r27= infinity d27= 3.000 N 15= 1.51680 nu15=64.20r28= infinity [0044]

[Page [12th] (r12) aspheric surface data] epsilon=1.0000, A4=-0.90791x10-4, A6=-0.27514x10-6, A8=-0.37035x10-8 [page [18th] (r18) aspheric surface data] epsilon=1.0000, and A4= 0.28853x10-3, A6= 0.12716x10-5, A8= 0.10778x10-7 [page [20th] (r20) aspheric surface data] epsilon=1.0000[0045]

<<example 2>>

f= 7.5 to 25.5 to 50.6, and FNO=2.48-3.07-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 62.012 d1= 1.200 N

1= 1.79850 nu1= 22.60r2= 50.059 d2= 3.893 N 2= 1.49310 nu2= 83.58r3= 264.139 d3= 0.100r4= 57.561 d4= 2.818 N 3= 1.49310 nu3= 83.58r5= 155.066 d5= 1.000-30.739-48.448r6= 29.965 d6= 0.800 N 4= 1.75450 nu4= 51.57r7= 9.032 d7= 7.570r8= -52.559 d8= 0.800 N 5= 1.75450 nu5= 51.57r9=21.530 d9= 4.134 N 6= 1.79850 nu6= 22.60r10= -18.800d10= 0.486r11=-15.910 d11= 0.800 N 7= 1.84666 nu7= 23.82r12*=-107.564 d12=25.513-4.405-1.000r13= infinity (ST) d13= 0.800r14= 13.086 d14= 1.832 N 8= 1.80750 nu8= 35.43r15= 84.611 d15= 3.644r16= 15.627 d16= 2.756 N 9= 1.75450 nu9= 51.57r17= -12.357 d17= 0.800 N 10= 1.84666 nu10=23.82r18= 9.111 d18= 0.100r19=7.143 d19=1.343 N 11= 1.52510 nu11=56.38r20*= 13.828 d20= 2.118r21= 31.671 d21= 1.530N 12= 1.79850 nu12=22.60r22= -35.431 d22= 1.000-5.669 - 4.095r23= 26.961 d23= 0.800 N 13= 1.85000 nu13=40.04r24= 9.331 d24= 2.307r25= 11.028 d25= 1.289 N 14= 1.79850 nu14=22.60r26= 14.503 d26= 2.123-2.989-8.644r27=-130.604 d27= 1.347 N 15= 1.79850 nu15=22.60r28= -33.480d28= 0.858r29=infinity d29= 3.000 N 16= 1.51680 nu16=64.20r30= infinity [0046]

[page [12th] (r12) aspheric surface data] -- epsilon= 1.0000 and A4=-0.44023x10 -4 and A6=-0.52908x10 -7, A8=-0.21921x10-8 [page [20th]

(r20) aspheric surface data] epsilon=1.0000, and A4= -- 0.52117x10-3 and A -- 6= 0.41505x10-5 and A -- 8= 0.98968x10-7 [0047]

<<example 3>>

f= 7.4 to 23.0 to 49.5, and FNO=2.22-2.64-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 63.356 d1= 1.200 N 1= 1.79850 nu1= 22.60r2= 49.435 d2= 4.655 N 2= 1.49310 nu2= 83.58r3= 579.022 d3= 0.100r4= 35.101 d4= 4.695 N 3= 1.49310 nu3= 83.58r5= 120.463 d5= 1.000-20.900-28.705r6= 70.488 d6= 0.800 N 4= 1.78831 nu4= 47.32r7= 8.526 d7= 5.198r8= -90.436 d8= 0.800 N 5= 1.75450 nu5= 51.57r9=-785.404 d9= 2.674 N 6= 1.84666 nu6= 23.82r10= -17.628d10= 0.515r11=-14.870 d11= 0.800 N 7= 1.48749 nu7= 70.44r12= 45.809 d12= 1.366r13= -26.330 d13= 1.344 N8= 1.84666nu8= 23.82r14*=-30.311 d14=23.018-5.870-1.000r15= infinity (ST) d15= 0.800r16= 11.633 d16= 2.165 N 9= 1.80420 nu9= 46.50r17= 78.024 d17= 4.756r18=-96.322 d18= 1.561 N 10= 1.75450 nu10=51.57r19= -14.086 d19= 0.800 N 11= 1.84666 nu11=23.82r20*= 20.484 d20= 0.155r21=10.937 d21= 2.506 N 12= 1.48749 nu12=70.44r22*=-29.274 d22= 2.186r23= 90.101 d23= 1.374 N 13= 1.79850 nu13=22.60r24= -61.263 d24= 1.000-4.206 - 1.000r25= 29.977 d25= 0.800 N 14= 1.85000 nu14=40.04r26=

10.683 d26= 3.356r27= 11.252 d27= 1.235 N 15= 1.79850 nu15=22.60r28= 13.786 d28= 1.399-3.217 - 16.734r29= 22.159 d29= 1.546 N 16= 1.79850 nu16=22.60r30= 89.583 d30= 1.176r31=infinity d31= 3.000 N 17= 1.51680 nu17=64.20r32= infinity [0048]

[Page [14th] (r14) aspheric surface data] epsilon=1.0000, A4=-0.55658x10-4, A6=-0.18456x10-6, A8=-0.60664x10-8 [page [20th] (r20) aspheric surface data] epsilon=1.0000, and A4= 0.28248x10-3, A6= 0.17454x10-5, A8= 0.32532x10-7 [page [22nd] (r22) aspheric surface data] epsilon=1.0000[0049]

<<example 4>>

f= 7.4 to 35.9 to 49.6, and FNO=2.88-3.04-3.63 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 60.590 d1= 1.200 N 1= 1.84666 nu1= 23.82r2= 47.616 d2= 5.549 N 2= 1.49310 nu2= 83.58r3= 603.843 d3= 0.100r4= 39.319 d4= 4.325 N 3= 1.49310 nu3= 83.58r5= 105.185 d5= 1.000-32.186-36.134r6= 50.395 d6= 0.800 N 4= 1.85000 nu4= 40.04r7= 8.808 d7= 5.350r8= -22.935 d8= 0.800 N 5= 1.85000 nu5= 40.04r9=16.429 d9= 5.107 N 6= 1.71736 nu6= 29.50r10= -17.500d10= 0.100r11*= 54.395 d11= 2.000 N 7= 1.84506 nu7=23.66r12= 1000.000 d12= 1.278r13=-19.690 d13= 0.800 N8= 1.75450nu8= 51.57r14= -77.927 d14=22.063-1.444-1.300r15=

infinity (ST) d15= 0.800r16= 12.783 d16= 2.898 N 9= 1.85000 nu9= 40.04r17= 105.738 d17= 3.453r18*=37.506 d18= 2.226 N 10= 1.84506 nu10=23.66r19= 9.939 d19= 1.104r20=12.962 d20= 4.135 N 11= 1.69680 nu11=55.43r21= -8.915 d21= 0.800 N 12= 1.84666 nu12=23.82r22=26007.802 d22= 1.396r23=186.617 d23= 2.183 N 13= 1.83350 nu13=21.00r24= -21.147 d24= 1.810-6.450-1.000r25= 38.703 d25= 0.800 N 14= 1.85000 nu14=40.04r26= 13.436 d26= 4.085r27= 14.114 d27= 1.362 N 15= 1.83350 nu15=21.00r28= 18.526 d28= 1.000-5.337 - 17.559r29= 16.513 d29= 1.967 N 16= 1.48749 nu16=70.44r30= 44.597d30= 1.479r31= infinity d31= 3.000 N17=1.51680nu17=64.20r32= infinity [0050]

[page [11th] (r11) aspheric surface data] -- epsilon= 1.0000 and A4= 0.40063x10 -4 and A6= 0.39528x10 -6, A8=-0.29922x10-8 [page [18th] (r18) aspheric surface data] epsilon=1.0000, and A4= -0.11545x10-3 and A6= -0.96168x10-6 and A -- 8= 0.16989x10-7 [0051]

<<example 5>>

f= 8.9 to 33.7 to 84.8, and FNO=2.43-3.17-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 171.427 d1= 1.497 N 1= 1.84666 nu1= 23.82r2= 114.665 d2= 6.918 N 2= 1.49310 nu2= 83.58r3=

-850.123 d3= 0.100r4= 96.816 d4= 4.523 N 3= 1.49310 nu3= 83.58r5= 348.049 d5= 2.486-40.898-95.614r6*= 24.483 d6= 2.000 N 4= 1.75450 nu4= 51.57r7= 12.754 d7= 11.729r8= -33.584 d8= 0.800 N 5= 1.52208 nu5= 65.92r9=21.063 d9= 4.926 N 6= 1.84705 nu6= 25.00r10= -81.045d10= 0.838r11=-40.184 d11= 0.800 N 7= 1.74495 nu7= 24.47r12= 99.136 d12=41.883-2.565-1.250r13= infinity (ST) d13= 1.500r14= 12.436 d14= 3.485 N 8= 1.75450 nu8= 51.57r15=-172.448 d15= 1.166r16= 375.028 d16= 0.800 N 9= 1.71675 nu9= 26.91r17= 30.185 d17= 1.000-1.169 - 1.244r18*= 16.888 d18= 1.922 N 10= 1.84666 nu10=23.82r19= 11.475 d19= 1.988-11.017 - 23.820r20*= 25.613 d20= 0.800 N 11= 1.75000 nu11=25.14r21= 14.963 d21= 0.077r22= 15.312 d22= 1.202 N 12= 1.75450 nu12=51.57r23= 16.980 d23= 0.356r24= 16.249 d24= 6.391 N 13= 1.49310 nu13=83.58r25= -22.015 d25= 1.962r26= -13.823 d26= 3.437 N14=1.84666nu14=23.82r27=-14.151 d27= 2.000-12.427 - 6.704r28*= 20.728 d28= 2.834 N 15= 1.52510 nu15=56.38r29= 15.822 d29= 1.307r30= infinity d30= 3.000 N 16= 1.51680 nu16=64.20r31= infinity [0052]

[Page [6th] (r6) aspheric surface data] epsilon=1.0000 and A4= 0.66358x10-5, A6= 0.71481x10-9, A8= 0.49766x10-10 [page [18th] (r18) aspheric surface data] epsilon=1.0000, A4=-0.10218x10-3, A6=-0.12797x10-5, and A8=

0.10173x10-7, A10=-0.34395x10-9 [page [20th] (r20) aspheric surface data] epsilon=1.0000, A4=-0.34705x10-4, A6= 0.10595x10-6, A8=-0.43764x10-8, and A10= 0.17721x10-10 [page [28th] (r28) aspheric surface data] epsilon=1.0000, A4=-0.59570x10-5, A6=-0.55853x10-6, A8= 0.11878x10-7, A10=-0.14101x10-9[0053]

<<example 6>>

f= 7.1 to 53.0 to 68.6, and FNO=2.55-3.60-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 81.309 d1= 1.400 N 1= 1.84666 nu1= 23.86r2= 63.920 d2= 4.957 N 2= 1.49310 nu2= 83.58r3=-2566.999 d3= 0.100r4= 72.424 d4= 2.914 N 3= 1.49310 nu3= 83.58r5= 204.372 d5= 0.900-54.218-57.909r6*=-2187.849 d6= 1.200 N 4= 1.77250 nu4= 49.77r7*= 14.815 d7= 8.614r8= -22.207 d8= 1.500 N 5= 1.84668 nu5= 23.86r9=-39.485 d9= 0.100r10= 528.712 d10= 4.283N 6= 1.84666 nu6= 23.82r11= -27.851 d11= 1.412r12= -19.591 d12= 1.000 N 7= 1.49310 nu7= 83.58r13= -80.805 d13=40.111-0.619-0.100r14= infinity (ST) d14= 1.200r15*= 20.034 d15= 3.327 N 8= 1.77112 nu8= 48.87r16= 2658.231 d16= 0.100r17=24.453 d17= 1.028 N 9= 1.61287 nu9= 33.36r18*= 9.473 d18= 0.432r19= 12.678 d19= 2.612 N 10= 1.75450 nu10=51.57r20=-167.012 d20=

0.537-1.270 - 1.348r21= -32.395 d21= 6.981 N 11= 1.64379 nu11=56.31r22= -11.929 d22= 0.100r23*=-13.515 d23= 1.708N 12= 1.63456 nu12=31.17r24*= 24.372 d24= 0.263-19.944 - 27.790r25= 19.740 d25= 4.770 N 13= 1.79850 nu13=22.60r26= 13.053 d26= 0.100r27=13.309 d27= 5.694 N 14= 1.68636 nu14=54.20r28=-129.207 d28= 4.148-5.575 - 2.763r29= infinity d29= 3.000 N 15= 1.51680 nu15=64.20r32= infinity [0054]

[Page [6th] (r6) aspheric surface data] epsilon=1.0000 and A4= 0.29074x10-4, A6=-0.89940x10-7, A8= 0.16625x10-9 [page [7th] (r7) aspheric surface data] epsilon=1.0000, A4= 0.44003x10-5, A6= 0.99743x10-8, the A8=-0.48301x10-9[15th page Aspheric surface data]epsilon=1.0000 of (r15), A4=-0.11178x10-3, A6= 0.10605x10-5, A8=-0.21375x10-7, A10= 0.22240x10-9 [page [18th] (r18) aspheric surface data] epsilon=1.0000, A4=-0.24094x10-3 and A6= 0.11663x10-5, A8=-0.57504x10-7, A10= 0.66415x10-9 [page [23rd] (r23) aspheric surface data] epsilon=1.0000, A4= 0.12224x10-3, A6=-0.66295x10-5, A8=0.74249x10-7 [page [24th] (r24) aspheric surface data] epsilon=1.0000, A4= 0.29363x10-3, A6=-0.57030x10-5, A8= 0.80185x10-7[0055]

<<example 7>>

f= 7.1 to 20.0 to 49.0, and FNO=2.50-3.03-3.66 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 111.111 d1= 1.400 N 1= 1.79850 nu1= 22.60r2= 85.390 d2= 4.303 N 2= 1.49310 nu2= 83.58r3=-1831.972 d3= 0.100r4= 43.431 d4= 4.988 N 3= 1.49310 nu3= 83.58r5= 130.083 d5= 0.900-24.171-43.681r6= 35.035 d6= 1.200 N 4= 1.75450 nu4= 51.57r7= 10.040 d7= 4.791r8= -96.605 d8= 1.100 N 5= 1.75450 nu5= 51.57r9=15.175 d9= 1.925r10*= 25.398 d10= 3.981N 6= 1.84666 nu6= 23.82r11*=-43.373 d11= 1.258r12= -15.932 d12= 1.000 N 7= 1.48749 nu7= 70.44r13=-134.899 d13=20.871-5.426-0.600r14= infinity (ST) d14= 0.600r15= 11.251 d15= 2.129 N 8= 1.75450 nu8= 51.57r16= 422.558 d16= 4.585r17*=-39.509 d17= 1.500 N 9= 1.70395 nu9= 26.41r18*= 12.891 d18= 0.596r19=12.874 d19= 2.614 N 10= 1.48749 nu10=70.44r20= -14.240 d20= 1.806-1.837-3.682r21=-8157.937 d21= 0.800 N 11= 1.71649 nu11=25.74r22= 13.228 d22= 0.445r23= 13.631 d23= 1.919N 12= 1.48749 nu12=70.44r24= 668.856 d24= 3.002-1.300 - 12.240r25= 31.322 d25= 1.691 N 13= 1.79850 nu13=22.60r26= 217.261 d26= 0.500-9.743 - 7.994r27= 18.461 d27= 4.643 N 14= 1.79850 nu14=22.60r28= -11.955 d28= 0.460 N 15= 1.83724 nu15=30.17r26= 21.532 d29= 0.900r30= infinity d27= 3.000 N 16= 1.51680

nu16=64.20r31= infinity [0056]

The [10th side Aspheric surface data]epsilon=1.0000 of (r10), and A4= 0.34767x10-4 and A6= 0.63939x10-7, A8=-0.15659x10-8 [page [11th] (r11) aspheric surface data] epsilon=1.0000, and A4= -0.11239x10-4 and A6= -0.50907x10-7 -- the A8=-0.20881x10-8[17th page Aspheric surface data]epsilon=1.0000 of (r17), A4=-0.53164x10-3, A6= 0.11706x10-4, A8=-0.13639x10-6 [page [18th] (r18) aspheric surface data] epsilon=1.0000, A4=-0.23930x10-3, and A6= 0.14046x10-4, A8=-0.15638x10-6[0057]

<<example 8>>

f= 7.5 to 45.0 to 71.5, and FNO=2.17-2.89-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 65.664 d1= 1.200 N 1= 1.75518 nu1= 29.92r2= 47.591 d2= 5.244 N 2= 1.49310 nu2= 83.58r3= 217.318 d3= 0.100r4= 51.066 d4= 4.398 N 3= 1.49310 nu3= 83.58r5= 185.539 d5= 1.000-45.300-49.091r6= 45.239 d6= 0.800 N 4= 1.75450 nu4= 51.57r7= 10.516 d7= 7.570r8= -40.143 d8= 0.800 N 5= 1.80223 nu5= 44.75r9=23.630 d9= 5.046 N 6= 1.79123 nu6= 22.82r10= -18.887d10= 0.656r11=-15.690 d11= 0.800 N 7= 1.84666 nu7= 23.82r12*=-43.100 d12=35.757-5.453-1.000r13= infinity (ST) d13= 0.800r14= 13.866 d14= 2.194 N 8= 1.78923 nu8= 46.34r15=

74.387 d15= 5.348r16= 13.726 d16= 3.113 N 9= 1.73284 nu9= 52.33r17= -13.373 d17= 0.800 N 10= 1.84758 nu10=26.81r18= 8.964 d18= 0.100r19=7.206 d19=1.439 N 11= 1.52510 nu11=56.38r20*= 14.351 d20= 2.601r21= 21.969 d21= 1.379N 12= 1.79850 nu12=22.60r22=-1723.989 d22= 1.000-3.838 - 2.749r23= 342.635 d23= 0.800 N 13= 1.66384 nu13=35.98r24= 8.966 d24= 3.000r25= 24.255 d25= 1.566 N 14= 1.79850 nu14=22.60r26*= 120.635 d26= 1.000-5.947 - 14.698r27= 25.459 d27= 1.667 N 15= 1.79850 nu15=22.60r28= 884.189d28= 1.019r29=infinity d29= 3.000 N 16= 1.51680 nu16=64.20r30= infinity [0058]

[Page [12th] (r12) aspheric surface data] epsilon=1.0000, A4=-0.28880x10-4, A6=-0.39221x10-7, A8=-0.58769x10-9 [page [20th] (r20) aspheric surface data] epsilon=1.0000, and A4= 0.44180x10-3 and A6= 0.35794x10-5, A8= 0.93325x10-7 [page [26th] (r26) aspheric surface data] epsilon=1.0000, A4=-0.73523x10-4, A6=-0.60792x10-6, A8=-0.59550x10-8[0059]

<<example 9>>

f= 7.5 to 54.0 to 86.0, and FNO=2.10-2.84-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 90.273 d1= 1.200 N 1= 1.83304 nu1= 41.53r2= 50.609 d2= 6.584 N 2= 1.49310 nu2= 83.58r3=

491.903 d3= 0.100r4= 50.212 d4= 5.970 N 3= 1.49310 nu3= 83.58r5= 293.841 d5= 1.000-56.319-60.499r6= 53.739 d6= 0.800 N 4= 1.75450 nu4= 51.57r7= 11.112 d7= 7.570r8= -105.475 d8= 0.800 N 5= 1.76442 nu5= 49.91r9=16.958 d9= 6.473 N 6= 1.77039 nu6= 23.51r10= -22.262d10= 0.563r11=-19.229 d11= 0.800 N 7= 1.84666 nu7= 23.82r12*=-140.106 d12=34.166-4.250-1.000r13= infinity (ST) d13= 0.800r14= 14.098 d14= 2.180 N 8= 1.83255 nu8= 41.58r15= 75.309 d15= 4.215r16= 13.256 d16= 3.141 N 9= 1.71070 nu9= 53.17r17= -15.268 d17= 0.800 N 10= 1.80992 nu10=25.83r18= 7.879 d18= 0.274r19=7.000 d19=1.461 N 11= 1.52510 nu11=56.38r20*= 13.820 d20= 3.133r21= 21.375 d21= 1.301N 12= 1.79850 nu12=22.60r22= 2254.283 d22= 1.000-3.613-1.086r23= 2109.616 d23= 0.800 N 13= 1.64794 nu13=36.75r24= 9.838 d24= 2.907r25= 21.069 d25= 1.316 N 14= 1.79850 nu14=22.60r26*= 59.731 d26= 1.000-6.745 - 18.339r27= 21.610 d27= 1.710 N 15= 1.84666 nu15=23.82r28= 97.515d28= 1.154r29=infinity d31= 3.000 N 16= 1.51680 nu16=64.20r30= infinity [0060]

[Page [12th] (r12) aspheric surface data] epsilon=1.0000, A4=-0.26006x10-4, A6=-0.12948x10-7, A8=-0.69799x10-9 [page [20th] (r20) aspheric surface data] epsilon=1.0000, and A4= 0.39398x10-3, A6= 0.33896x10-5, A8=

0.11071x10-6 [page [26th] (r26) aspheric surface data] epsilon=1.0000, A4=-0.53134x10-4, A6=-0.59377x10-6, and A8= 0.30506x10-8 [0061]

[Table 1]

[0062]

[Table 2]

[0063]

[Effect of the Invention] The image pick-up lens equipment which has the high variable-power zoom lens system which could realize the type which has the performance which exceeds forward, negative, forward, and a forward type by compactability according to this invention, had the high engine performance which a variable-power ratio can use by 7 times to about 10 times, and the f number can use also as optical system for the image sensors of the latest small pixel pitch about by 2.5 to four especially as explained above, and was excellent in compactability is realizable. And if this invention is applied to a digital camera; video camera; digital video unit, a personal computer, a mobile computer, a cellular phone, an information personal digital assistant (PDA), etc. at built-in or

the camera by which external is carried out, it can be contributed to miniaturization of these devices, a raise in variable power, and high performance-ization.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The lens block diagram of the gestalt (example 1) of the 1st operation.

[Drawing 2] The lens block diagram of the gestalt (example 2) of the 2nd operation.

[Drawing 3] The lens block diagram of the gestalt (example 3) of the 3rd operation.

[Drawing 4] The lens block diagram of the gestalt (example 4) of the 4th operation.

[Drawing 5] The lens block diagram of the gestalt (example 5) of the 5th operation.

[Drawing 6] The lens block diagram of the gestalt (example 6) of the 6th operation.

[Drawing 7] The lens block diagram of the gestalt (example 7) of the 7th operation.

[Drawing 8] The lens block diagram of the gestalt (example 8) of the 8th operation.

[Drawing 9] The lens block diagram of the gestalt (example 9) of the 9th

operation.

[Drawing 10] The aberration Fig. in the infinite distance photography condition of an example 1.

[Drawing 11] The aberration Fig. in the infinite distance photography condition of an example 2.

[Drawing 12] The aberration Fig. in the infinite distance photography condition of an example 3.

[Drawing 13] The aberration Fig. in the infinite distance photography condition of an example 4.

[Drawing 14] The aberration Fig. in the infinite distance photography condition of an example 5.

[Drawing 15] The aberration Fig. in the infinite distance photography condition of an example 6.

[Drawing 16] The aberration Fig. in the infinite distance photography condition of an example 7.

[Drawing 17] The aberration Fig. in the infinite distance photography condition of an example 8.

[Drawing 18] The aberration Fig. in the infinite distance photography condition of

an example 9.

[Drawing 19] The aberration Fig. in the contiguity photography condition (D= 0.5m) of an example 1.

[Drawing 20] The aberration Fig. in the contiguity photography condition (D= 0.5m) of an example 2.

[Drawing 21] The aberration Fig. in the contiguity photography condition (D= 0.5m) of an example 3.

[Drawing 22] The aberration Fig. in the contiguity photography condition (D= 0.5m) of an example 4.

[Drawing 23] The aberration Fig. in the contiguity photography condition (D= 0.5m) of an example 5.

[Drawing 24] The aberration Fig. in the contiguity photography condition (D= 0.5m) of an example 8.

[Drawing 25] The aberration Fig. in the contiguity photography condition (D= 0.5m) of an example 9.

[Drawing 26] The mimetic diagram showing the outline optical configuration of the image pick-up lens equipment concerning this invention.

[Description of Notations]

TL -- Taking-lens system (zoom lens system)

SR -- Image sensor

Gr1 -- The 1st lens group

Gr2 -- The 2nd lens group

Gr3 -- The 3rd lens group

Gr4 -- The 4th lens group

Gr5 -- The 5th lens group

Gr6 -- The 6th lens group

PL -- Glass plate (plane-parallel plate)

ST -- Diaphragm

AX -- Optical axis

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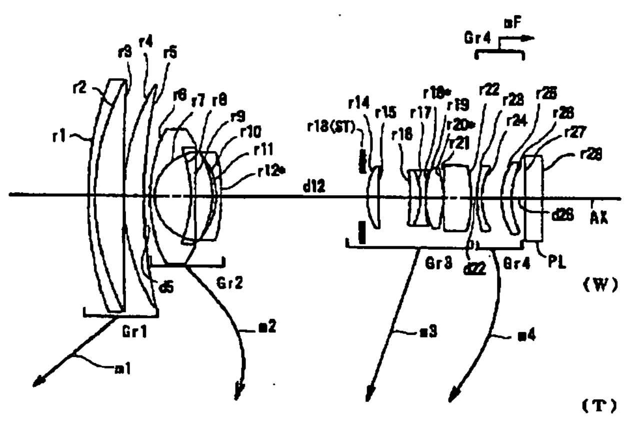
最終頁に続く

(54)【発明の名称】　撮像レンズ装置

(57)【要約】
【課題】　変倍比7倍～10倍程度、Ｆナンバー2.5～4程度、最先端の小さな画素ピッチの撮像素子用の光学系として使用できる高い性能を持ち、コンパクト性に優れた高変倍ズームレンズ系を有する撮像レンズ装置を提供する。
【解決手段】　ズームレンズ系は、物体側より順に、正パワーの第１レンズ群(Gr1)、負パワーの第２レンズ群(Gr2)、正パワーの第３レンズ群(Gr3)、負パワーの第４レンズ群(Gr4)を含み、条件式：1.1＜f1／fT＜2.5{f1：第１レンズ群(Gr1)の焦点距離, fT：望遠端(T)での全系の焦点距離}を満足する。



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【特許請求の範囲】

【請求項１】　複数のレンズ群から成りレンズ群間隔を変えることにより変倍を行うズームレンズ系と、そのズームレンズ系により形成された光学像を電気的な信号に変換する撮像素子と、を備えた撮像レンズ装置であって、

前記ズームレンズ系が、物体側より順に、正のパワーを有する第１レンズ群と、負のパワーを有する第２レンズ群と、正のパワーを有する第３レンズ群と、負のパワーを有する第４レンズ群と、を含み、以下の条件式(1)を満足することを特徴とする撮像レンズ装置；

$1.1 < f1/fT < 2.5$　…(1)

ただし、

f1：第１レンズ群の焦点距離、

fT：望遠端での全系の焦点距離、

である。

【請求項２】　前記第４レンズ群が光軸方向に移動することによってフォーカシングが行われ、さらに以下の条件式(2)を満足することを特徴とする請求項１記載の撮像レンズ装置；

$0.3 < |f4/fT| < 2$　…(2)

ただし、

f4：第４レンズ群の焦点距離、

である。

【請求項３】　広角端から望遠端へのズーミングにおいて、前記第１レンズ群が移動し、前記第３レンズ群と前記第４レンズ群との間隔が広角端から中間焦点距離までは増大し中間焦点距離から望遠端までは減少することを特徴とする請求項１又は請求項２記載の撮像レンズ装置。

【請求項４】　複数のレンズ群から成りレンズ群間隔を変えることにより変倍を行うズームレンズ系と、そのズームレンズ系により形成された光学像を電気的な信号に変換する撮像素子と、を備えた撮像レンズ装置であって、前記ズームレンズ系が、物体側より順に、正のパワーを有する第１レンズ群と、負のパワーを有する第２レンズ群と、正のパワーを有する第３レンズ群と、負のパワーを有する第４レンズ群と、を含み、ズーミングにおいて第１レンズ群が移動し、以下の条件式(3)を満足することを特徴とする撮像レンズ装置；

$0.3 < D_{34W}/D_{34T} < 2.5$　…(3)

ただし、

D_{34W}：広角端における第３レンズ群と第４レンズ群との間の空気間隔、

D_{34T}：望遠端における第３レンズ群と第４レンズ群との間の空気間隔、

である。

【請求項５】　広角端から望遠端へのズーミングにおいて、前記第４レンズ群が物体側へ移動することを特徴とする請求項４記載の撮像レンズ装置。

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【請求項６】　広角端から望遠端へのズーミングにおいて、前記第３レンズ群と前記第４レンズ群との間隔が広角端から中間焦点距離までは増大し中間焦点距離から望遠端までは減少することを特徴とする請求項４又は請求項５記載の撮像レンズ装置。

【請求項７】　フォーカシングが前記第４レンズ群の移動によって行われ、さらに以下の条件式(4)を満足することを特徴とする請求項４，５又は６記載の撮像レンズ装置；

$0.5 < \beta_{4W} < 2$　…(4)

ただし、

β_{4W}：広角端における第４レンズ群の横倍率、

である。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は撮像レンズ装置に関するものであり、特に被写体の映像を光学系により光学的に取り込んで撮像素子により電気的な信号として出力する撮像レンズ装置｛例えば、デジタルカメラ；ビデオカメラ；デジタルビデオユニット，パーソナルコンピュータ，モバイルコンピュータ，携帯電話，情報携帯端末（ＰＤＡ：Personal Digital Assistant)等に内蔵又は外付けされるカメラの主たる構成要素｝、なかでもコンパクトで高変倍のズームレンズ系を備えた撮像レンズ装置に関するものである。

【０００２】

【従来の技術】デジタルカメラ用の高変倍ズームレンズとしては、物体側より順に、正のパワーを有する第１レンズ群と、負のパワーを有する第２レンズ群と、正のパワーを有する第３レンズ群と、正のパワーを有する第４レンズ群と、から成るタイプが、従来よりその主流を占めている(例えば特開平４－２９６８０９号)。これは正・負・正・正タイプがコンパクト性に優れているためである。

【０００３】また、高い変倍比を達成したズームレンズとしては、物体側より順に、正のパワーを有する第１レンズ群と、負のパワーを有する第２レンズ群と、正のパワーを有する第３レンズ群と、負のパワーを有する第４レンズ群と、から成るもの(例えば特開平５－３４１１８９号)や、物体側より順に、正のパワーを有する第１レンズ群と、負のパワーを有する第２レンズ群と、正のパワーを有する第３レンズ群と、負のパワーを有する第４レンズ群と、正のパワーを有する第５レンズ群と、から成るもの(例えば特開平１０－１１１４５７号)も知られている。

【０００４】

【発明が解決しようとする課題】特開平５－３４１１８９号公報で提案されている正・負・正・負タイプのズームレンズは、ズーミングにおいて第１レンズ群が固定であるため、更なる高変倍比化や撮像素子の小ピッチ化に

伴う更なる高性能化には不向きである。また特開平１０－１１１４５７号公報で提案されている正・負・正・負・正タイプのズームレンズは、ズーミングにおいて第１レンズ群も移動するが、特に第１，第２レンズ群のパワーが強いため各群で発生する諸収差は大きくなる。したがって、更なる高変倍比化や撮像素子の小ピッチ化に伴う更なる高性能化を実現することは困難である。また、第４レンズ群が負群より成る正・負・正・負を含むタイプは、正・負・正・正のタイプと比べてコンパクト性でやや劣るという欠点もある。

【０００５】本発明はこのような状況に鑑みてなされたものであって、その目的は、コンパクト性で正・負・正・正タイプを超えるパフォーマンスを持つタイプを実現することにあり、特に、変倍比が7倍～10倍程度、Ｆナンバーが2.5～4程度で、最先端の小さな画素ピッチの撮像素子用の光学系としても使用できる高い性能を持ち、かつ、コンパクト性に優れた高変倍ズームレンズ系を有する撮像レンズ装置を提供することを目的とする。

【０００６】

【課題を解決するための手段】上記目的を達成するために、第１の発明の撮像レンズ装置は、複数のレンズ群から成りレンズ群間隔を変えることにより変倍を行うズームレンズ系と、そのズームレンズ系により形成された光学像を電気的な信号に変換する撮像素子と、を備えた撮像レンズ装置であって、前記ズームレンズ系が、物体側より順に、正のパワーを有する第１レンズ群と、負のパワーを有する第２レンズ群と、正のパワーを有する第３レンズ群と、負のパワーを有する第４レンズ群と、を含み、以下の条件式(1)を満足することを特徴とする。

$1.1 < f1/fT < 2.5$ …(1)

ただし、

f1：第１レンズ群の焦点距離、

fT：望遠端での全系の焦点距離、

である。

【０００７】第２の発明の撮像レンズ装置は、上記第１の発明の構成において、前記第４レンズ群が光軸方向に移動することによってフォーカシングが行われ、さらに以下の条件式(2)を満足することを特徴とする。

$0.3 < |f4/fT| < 2$ …(2)

ただし、

f4：第４レンズ群の焦点距離、

である。

【０００８】第３の発明の撮像レンズ装置は、上記第１又は第２の発明の構成において、広角端から望遠端へのズーミングにおいて、前記第１レンズ群が移動し、前記第３レンズ群と前記第４レンズ群との間隔が広角端から中間焦点距離までは増大し中間焦点距離から望遠端までは減少することを特徴とする。

【０００９】第４の発明の撮像レンズ装置は、複数のレンズ群から成りレンズ群間隔を変えることにより変倍を行うズームレンズ系と、そのズームレンズ系により形成された光学像を電気的な信号に変換する撮像素子と、を備えた撮像レンズ装置であって、前記ズームレンズ系が、物体側より順に、正のパワーを有する第１レンズ群と、負のパワーを有する第２レンズ群と、正のパワーを有する第３レンズ群と、負のパワーを有する第４レンズ群と、を含み、ズーミングにおいて第１レンズ群が移動し、以下の条件式(3)を満足することを特徴とする。

$0.3 < D_{34W} / D_{34T} < 2.5$ …(3)

ただし、

D_{34W} ：広角端における第３レンズ群と第４レンズ群との間の空気間隔、

D_{34T} ：望遠端における第３レンズ群と第４レンズ群との間の空気間隔、

である。

【００１０】第５の発明の撮像レンズ装置は、上記第４の発明の構成において、広角端から望遠端へのズーミングにおいて、前記第４レンズ群が物体側へ移動することを特徴とする。

【００１１】第６の発明の撮像レンズ装置は、上記第４又は第５の発明の構成において、広角端から望遠端へのズーミングにおいて、前記第３レンズ群と前記第４レンズ群との間隔が広角端から中間焦点距離までは増大し中間焦点距離から望遠端までは減少することを特徴とする。

【００１２】第７の発明の撮像レンズ装置は、上記第４，第５又は第６の発明の構成において、フォーカシングが前記第４レンズ群の移動によって行われ、さらに以下の条件式(4)を満足することを特徴とする。

$0.5 < \beta_{W4} < 2$ …(4)

ただし、

β_{W4} ：広角端における第４レンズ群の横倍率、

である。

【００１３】

【発明の実施の形態】以下、本発明を実施した撮像レンズ装置を、図面を参照しつつ説明する。被写体の映像を光学的に取り込んで電気的な信号として出力する撮像レンズ装置は、被写体の静止画撮影や動画撮影に用いられるカメラ｛例えば、デジタルカメラ；ビデオカメラ；デジタルビデオユニット，パーソナルコンピュータ，モバイルコンピュータ，携帯電話，情報携帯端末（ＰＤＡ）等に内蔵又は外付けされるカメラ｝の主たる構成要素である。その撮像レンズ装置は、例えば図２６に示すように、物体(被写体)側から順に、物体の光学像を形成する撮影レンズ系(TL)と、光学的ローパスフィルター等に相当する平行平面板(PL)と、撮影レンズ系(TL)により形成された光学像を電気的な信号に変換する撮像素子(SR)と、で構成される。

【００１４】後述する各実施の形態では、複数のレンズ群から成るズームレンズ系が撮影レンズ系(TL)として用

いられ、複数のレンズ群が光軸(AX)に沿って移動し、レンズ群間隔を変えることにより変倍が行われる。撮像素子(SR)としては、例えば複数の画素から成るＣＣＤ(Charge Coupled Device)やＣＭＯＳ(Complementary Metal Oxide Semiconductor)センサー等の固体撮像素子が用いられ、ズームレンズ系により形成された光学像が電気的な信号に変換される。またズームレンズ系で形成されるべき光学像は、撮像素子(SR)の画素ピッチにより決定される所定の遮断周波数特性を有する光学的ローパスフィルター(PL)を通過することにより、電気的な信号に変換される際に発生するいわゆる折り返しノイズが最小化されるように、空間周波数特性が調整される。撮像素子(SR)で生成した信号は、必要に応じて所定のデジタル画像処理や画像圧縮処理等が施されてデジタル映像信号としてメモリー(半導体メモリー，光ディスク等)に記録されたり、場合によってはケーブルを介したり赤外線信号に変換されたりして他の機器に伝送される。

【００１５】図１～図９は、第１～第９の実施の形態を構成するズームレンズ系にそれぞれ対応するレンズ構成図であり、広角端(W)でのレンズ配置を光学断面で示している。各レンズ構成図中の矢印mj(j=1,2,...)は、広角端(W)から望遠端(T)へのズーミングにおける第ｊレンズ群(Grj)の移動(ただし破線矢印mjはズーミングにおいて位置固定であることを表す。)をそれぞれ模式的に示しており、矢印mFは無限遠から近接へのフォーカシングにおけるフォーカス群の移動方向を示している。また、各レンズ構成図中、ri(i=1,2,3,...)が付された面は物体(被写体)側から数えてi番目の面であり、riに*印が付された面は非球面である。di(i=1,2,3,...)が付された軸上面間隔は、物体側から数えてi番目の軸上面間隔のうち、ズーミングにおいて変化する可変間隔である。

【００１６】各実施の形態のズームレンズ系はいずれも、物体側より順に、正のパワーを有する第１レンズ群(Gr1)と、負のパワーを有する第２レンズ群(Gr2)と、正のパワーを有する第３レンズ群(Gr3)と、負のパワーを有する第４レンズ群(Gr4)と、を含んでいる。そして、固体撮像素子(例えばＣＣＤ)を備えたカメラ(例えばデジタルカメラ)に用いられるズームレンズ系として、その像面側には光学的ローパスフィルター等に相当するガラス製の平行平面板、つまりガラス平板(PL)が配置されている。いずれの実施の形態においても、ガラス平板(PL)はズーミングにおいて位置固定であり、また第３レンズ群(Gr3)は最物体側に絞り(ST)を含んでいる。

【００１７】第１の実施の形態のズームレンズ系は、物体側より順に、正のパワーを有する第１レンズ群(Gr1)と、負のパワーを有する第２レンズ群(Gr2)と、正のパワーを有する第３レンズ群(Gr3)と、負のパワーを有する第４レンズ群(Gr4)と、から成る正・負・正・負タイプの４群ズームレンズである。第２～第４，第６，第８，第９の実施の形態のズームレンズ系は、物体側より順に、正のパワーを有する第１レンズ群(Gr1)と、負のパワーを有する第２レンズ群(Gr2)と、正のパワーを有する第３レンズ群(Gr3)と、負のパワーを有する第４レンズ群(Gr4)と、正のパワーを有する第５レンズ群(Gr5)と、から成る正・負・正・負・正タイプの５群ズームレンズである。

【００１８】第５の実施の形態のズームレンズ系は、物体側より順に、正のパワーを有する第１レンズ群(Gr1)と、負のパワーを有する第２レンズ群(Gr2)と、正のパワーを有する第３レンズ群(Gr3)と、負のパワーを有する第４レンズ群(Gr4)と、正のパワーを有する第５レンズ群(Gr5)と、負のパワーを有する第６レンズ群(Gr6)と、から成る正・負・正・負・正・負タイプの６群ズームレンズである。第７の実施の形態のズームレンズ系は、物体側より順に、正のパワーを有する第１レンズ群(Gr1)と、負のパワーを有する第２レンズ群(Gr2)と、正のパワーを有する第３レンズ群(Gr3)と、負のパワーを有する第４レンズ群(Gr4)と、正のパワーを有する第５レンズ群(Gr5)と、正のパワーを有する第６レンズ群(Gr6)と、から成る正・負・正・負・正・正タイプの６群ズームレンズである。

【００１９】いずれの実施の形態も、正・負・正・負で始まるズームタイプである。第３，第４レンズ群(Gr3,Gr4)が共に正パワーを有する正・負・正・正タイプと比べると、第４レンズ群(Gr4)を負レンズ群にした正・負・正・負を含むズームタイプでは、第３レンズ群(Gr3)と第４レンズ群(Gr4)のパワーの符号が違うため、第３，第４レンズ群(Gr3,Gr4)でより高い変倍比をかせぐことができ、高変倍を確保しやすいというメリットがある。なお、正・負・正・負を含むタイプとしては、(正・負・正・負)の４群タイプ；(正・負・正・負)・正，(正・負・正・負)・負の５群タイプ；(正・負・正・負)・正・正，(正・負・正・負)・正・負，(正・負・正・負)・負・正，(正・負・正・負)・負・負の６群タイプ等のバリエーションが挙げられる。

【００２０】各実施の形態のように物体側より順に正・負・正・負のズーム群を含むタイプのズームレンズ系においては、以下の条件式(1)を満足することが望ましい。これにより、コンパクトで高変倍のズームレンズ系を実現することができる。しかも、変倍比が7倍～10倍程度、Ｆナンバーが2.5～4程度で、最先端の小さな画素ピッチの撮像素子(SR)用の光学系としても使用できる高い性能を得ることができる。

$1.1 < f1/fT < 2.5$ …(1)

ただし、

f1：第１レンズ群(Gr1)の焦点距離、

fT：望遠端(T)での全系の焦点距離、

である。

【００２１】条件式(1)の下限を超えると、第１レンズ群(Gr1)のパワーが強くなりすぎて、特に望遠端(T)にお

ける球面収差を除去することが困難になる。また、条件式(1)の上限を超えると、第１レンズ群(Gr1)のパワーが弱くなりすぎて、特に望遠端(T)でのコンパクト性を確保することが困難になる。

【００２２】各実施の形態のように物体側より順に正・負・正・負のズーム群を含むタイプのズームレンズ系においては、第４レンズ群(Gr4)が光軸(AX)方向に移動することによってフォーカシングが行われ、さらに以下の条件式(2)を満足することが望ましい。これによって、より高い性能を確保したズームレンズ系を実現することができる。また、前記条件式(1)と共に条件式(2)を満足することが更に望ましい。

$0.3 < |f4/fT| < 2$ …(2)

ただし、

f4：第４レンズ群(Gr4)の焦点距離、

である。

【００２３】条件式(2)で示されるように第４レンズ群(Gr4)のパワーは比較的弱く、したがってレンズ枚数も第４レンズ群(Gr4)が最も少ない。このことから、レンズ重量の小さい第４レンズ群(Gr4)の光軸(AX)方向の移動(mF)によってフォーカシングを行うのが最適である。ただし、撮像素子(SR)におけるフォーカシングが可能なシステムを採用できるときには、撮像素子(SR)の移動によりフォーカシングを行うようにしても差し支えない。

【００２４】条件式(2)の下限を超えると、第４レンズ群(Gr4)のパワーが強くなりすぎて、特に望遠端(T)における近接時の性能劣化を除去することが困難になる。また、条件式(2)の上限を超えると、第４レンズ群(Gr4)のパワーが弱くなりすぎて、フォーカス時の第４レンズ群(Gr4)のレンズ移動量が大きくなりすぎてしまい、鏡胴全体のコンパクト性が損なわれる結果となる。

【００２５】また各実施の形態のように、広角端(W)から望遠端(T)へのズーミングにおいて、第１レンズ群(Gr1)が移動し、第３レンズ群(Gr3)と第４レンズ群(Gr4)との間隔が広角端(W)から中間焦点距離までは増大し中間焦点距離から望遠端(T)までは減少することが望ましく、これによってより高変倍のズームレンズ系を実現することができる。また、この特徴的なズーム構成においては条件式(1)や条件式(2)を満足することが更に望ましい。

【００２６】従来よりビデオカメラやデジタルカメラに用いられている光学系としては、製品全体として求められるコンパクト性と鏡胴構成の難易度とのバランスから、ズーミングにおいて第１レンズ群(Gr1)が固定されているタイプが主流であった。しかしながら、これからは更なるコンパクトネスと高変倍が求められる状況にあるため、第１レンズ群(Gr1)をズーミングにおいて可動にするのが望ましい。広角端(W)から望遠端(T)へのズーミングにおいて第１レンズ群(Gr1)を物体側へ動かすことにより、望遠端(T)において第２レンズ群(Gr2)に入射する各光線高さを小さくすることができ、諸収差の補正が行いやすくなる。また、広角端(W)から望遠端(T)へのズーミングにおいて、第３，第４レンズ群(Gr3,Gr4)の間隔が広角端(W)から中間焦点距離までは増大し中間焦点距離から望遠端(T)までは減少する構成とすることにより、中間焦点距離領域における像面湾曲を良好に補正することが可能となり、結果として高変倍のズームレンズ系を実現することができる。

【００２７】また各実施の形態のように、第２レンズ群(Gr2)中に非球面を配置することが望ましく、第２レンズ群(Gr2)に非球面を設けることによって、より広角で始まるズームレンズ系が得られる。広角端(W)の焦点距離をより小さくして撮影画角を大きくしようとすると、特に広角端(W)での歪曲補正が困難になる。この不具合を取り除くには、広角側での軸外の光線高さの比較的高い第２レンズ群(Gr2)に非球面を配置することが望ましく、これによって良好に歪曲収差を補正することができる。したがって、条件式(1)や条件式(2)を満たすとともに第２レンズ群(Gr2)中に非球面を配置することが、コンパクト性を保持しながら高い光学性能を得る上で更に望ましい。

【００２８】各実施の形態のように物体側より順に正・負・正・負のズーム群を含み、ズーミングにおいて第１レンズ群(Gr1)が移動するズームレンズ系にあっては、以下の条件式(3)を満足することが望ましい。これにより、コンパクトで高変倍のズームレンズ系を実現することができる。しかも、変倍比が7倍～10倍程度、Ｆナンバーが2.5～4程度で、最先端の小さな画素ピッチの撮像素子(SR)用の光学系としても使用できる高い性能を得ることができる。

$0.3 < D_{34W} / D_{34T} < 2.5$ …(3)

ただし、

D_{34W}：広角端(W)における第３レンズ群(Gr3)と第４レンズ群(Gr4)との間の空気間隔、

D_{34T}：望遠端(T)における第３レンズ群(Gr3)と第４レンズ群(Gr4)との間の空気間隔、

である。

【００２９】条件式(3)の下限を超えると、望遠端(T)における第３レンズ群(Gr3)と第４レンズ群(Gr4)との間の空気間隔が大きくなりすぎて、望遠端(T)でのコンパクト性を確保するのが困難になる。また、条件式(3)の上限を超えると、広角端(W)における第３レンズ群(Gr3)と第４レンズ群(Gr4)との間の空気間隔が大きくなりすぎて、広角端(W)でのコンパクト性を確保するのが困難になる。

【００３０】各実施の形態のように物体側より順に正・負・正・負のズーム群を含むズームレンズ系においては、前述したようにズーミングにおいて第１レンズ群(Gr1)が移動するだけでなく、広角端(W)から望遠端(T)へのズーミングにおいて、第４レンズ群(Gr4)が物体側へ

移動することが望ましい。これによって、第４レンズ群(Gr4)における変倍比を多くかせぐことができ、より高い変倍比を持ったズームレンズ系を実現することができる。またコンパクト性とのバランスをとる上で、条件式(3)を満たすようにするのが更に好ましい。

【００３１】また、各実施の形態のように物体側より順に正・負・正・負のズーム群を含むズームレンズ系においては、前述したように広角端(W)から望遠端(T)へのズーミングにおいて、第３レンズ群(Gr3)と第４レンズ群(Gr4)との間隔が広角端(W)から中間焦点距離までは増大し中間焦点距離から望遠端(T)までは減少することが望ましいが、これと同時に条件式(3)を満足することがコンパクト性を確保する上で更に望ましい。このように第３，第４レンズ群(Gr3,Gr4)をズーム移動させることによって、特に中間焦点距離領域で発生するアンダーの像面湾曲を良好に補正することができ、高い性能を維持したズームレンズ系を実現することができる。

【００３２】また各実施の形態のように物体側より順に正・負・正・負のズーム群を含むタイプのズームレンズ系においては、前述したようにフォーカシングが第４レンズ群(Gr4)の移動によって行われ、さらに以下の条件式(4)を満足することが望ましい。これによって、より良好な性能を持ったズームレンズ系を実現することができる。また、前記条件式(3)と共に条件式(4)を満足することが更に望ましい。

$0.5 < \beta_{W4} < 2$ …(4)

ただし、

β_{W4} ：広角端(W)における第４レンズ群(Gr4)の横倍率、

である。

【００３３】前述したように第４レンズ群(Gr4)のパワーは比較的弱く、したがってレンズ枚数も第４レンズ群(Gr4)が最も少ない。このことから、フォーカス群としてはレンズ重量の小さい第４レンズ群(Gr4)が最適である。ただし、撮像素子(SR)を用いたフォーカシングが可能なシステムを採用できるときには、撮像素子(SR)でフォーカシングを行うようにしても差し支えない。

【００３４】条件式(4)の下限を超えると、広角端(W)において第４レンズ群(Gr4)に分担される変倍率が小さくなり、負担を第３レンズ群(Gr3)に付加する必要が出てくる。このため、結果として第３レンズ群(Gr3)内での諸収差の除去が困難になる。また、条件式(4)の上限を超えると、第４レンズ群(Gr4)における変倍の負担が大きくなりすぎて、第４レンズ群(Gr4)内での諸収差の除去が困難になり、その結果、コンパクトなズームレンズ系が実現できなくなる。

【００３５】前述したように、第２レンズ群(Gr2)中に非球面を配置すればより広角で始まるズームレンズ系が得られる。広角端(W)の焦点距離をより小さくして撮影画角を大きくしようとすると、特に広角端(W)での歪曲補正が困難になる。この不具合を取り除くには、広角側での軸外の光線高さの比較的高い第２レンズ群(Gr2)に非球面を配置することが望ましく、これによって良好に歪曲収差を補正することができる。したがって、条件式(3)や条件式(4)を満たすとともに第２レンズ群(Gr2)中に非球面を配置することが、コンパクト性を保持しながら高い光学性能を得る上で更に望ましい。

【００３６】なお、第１～第９の実施の形態を構成している各レンズ群は、入射光線を屈折により偏向させる屈折型レンズ(つまり、異なる屈折率を有する媒質同士の界面で偏向が行われるタイプのレンズ)のみで構成されているが、これに限らない。例えば、回折により入射光線を偏向させる回折型レンズ，回折作用と屈折作用との組み合わせで入射光線を偏向させる屈折・回折ハイブリッド型レンズ，入射光線を媒質内の屈折率分布により偏向させる屈折率分布型レンズ等で、各レンズ群を構成してもよい。

【００３７】また各実施の形態において、光学的なパワーを有しない面(例えば、反射面，屈折面，回折面)を光路中に配置することにより、ズームレンズ系の前，後又は途中で光路を折り曲げてもよい。折り曲げ位置は必要に応じて設定すればよく、光路の適正な折り曲げにより、カメラの見かけ上の薄型化を達成することが可能である。また、ズーミングや沈胴によりカメラの厚さが変化することのない構成にすることも可能である。例えば、第１レンズ群(Gr1)を変倍時位置固定とし、その第１レンズ群(Gr1)の後ろにミラーを配置し、その反射面で光路を90°折り曲げれば、ズームレンズ系の前後方向の長さが一定になるため、カメラの薄型化を達成することができる。

【００３８】さらに各実施の形態では、ズームレンズ系の最終面と撮像素子(SR)との間に配置される平行平面板(PL)の形状の光学的ローパスフィルターの構成例を示したが、このローパスフィルターとしては、所定の結晶軸方向が調整された水晶等を材料とする複屈折型ローパスフィルターや、必要とされる光学的な遮断周波数の特性を回折効果により達成する位相型ローパスフィルター等が適用可能である。

【００３９】

【実施例】以下、本発明を実施した撮像レンズ装置に用いられるズームレンズ系の構成等を、コンストラクションデータ，収差図等を挙げて、更に具体的に説明する。ここで例として挙げる実施例１～９は、前述した第１～第９の実施の形態にそれぞれ対応しており、第１～第９の実施の形態を表すレンズ構成図(図１～図９)は、対応する実施例１～９のレンズ構成をそれぞれ示している。

【００４０】各実施例のコンストラクションデータにおいて、ri(i=1,2,3,...)は物体側から数えてi番目の面の曲率半径(mm)、di(i=1,2,3,...)は物体側から数えてi番目の軸上面間隔(mm)を示しており、Ni(i=1,2,3,...)，νi(i=1,2,3,...)は物体側から数えてi番目の光学要素の

ｄ線に対する屈折率(Nd),アッベ数(ｖd)を示している。また、コンストラクションデータ中、ズーミングにおいて変化する軸上面間隔は、広角端(短焦点距離端,W)～ミドル(中間焦点距離状態,M)～望遠端(長焦点距離端,T)での可変空気間隔である。各焦点距離状態(W),(M),(T)に対応する全系の焦点距離(f,mm)及びＦナンバー(FNO)を他のデータと併せて示し、また、近接時(撮影距離：D=0.5m)のフォーカシングにおける第４レンズ群(Gr4)の移動量(フォーカスデータ)を表１に示し、条件式対応値を表２に示す。

【００４１】曲率半径riに*印が付された面は、非球面で構成された面であることを示し、非球面の面形状を表わす以下の式(AS)で定義されるものとする。各実施例の非球面データを他のデータと併せて示す。

$$X(H)=(C0\cdot H^{2})/\{1+\sqrt{(1-\varepsilon\cdot C0^{2}\cdot H^{2})}\}+(A4\cdot H^{4}+A6\cdot H^{6}+A8\cdot H^{8}+A10\cdot H^{10}) \quad \cdots(AS)$$

ただし、式(AS)中、
X(H)：高さHの位置での光軸方向の変位量(面頂点基準)、
H　：光軸に対して垂直な方向の高さ、
C0　：近軸曲率(=1／曲率半径)、
ε　：２次曲面パラメータ、
Ai　：i次の非球面係数、
である。

【００４２】図１０～図２５は実施例１～実施例９の収差図であり、図１０～図１８は実施例１～実施例９の無限遠撮影状態での収差図、図１９～図２５は実施例１～５，８，９の近接撮影状態(撮影距離：D=0.5m)での収差図である。図１０～図２５中、(W)は広角端，(M)はミドル，(T)は望遠端における諸収差{左から順に、球面収差等，非点収差，歪曲収差である。Y'：最大像高(mm)}を示している。球面収差図において、実線(d)はｄ線に対する球面収差、一点鎖線(g)はｇ線に対する球面収差、破線(SC)は正弦条件を表している。非点収差図において、破線(DM)はメリディオナル面でのｄ線に対する非点収差を表しており、実線(DS)はサジタル面でのｄ線に対する非点収差を表わしている。また、歪曲収差図において実線はｄ線に対する歪曲％を表している。

【００４３】

《実施例１》

f=7.5～25.5～50.6,FNO=2.55～2.96～3.60

[曲率半径]	[軸上面間隔]	[屈折率]	[アッベ数]
r1= 63.832			
	d1= 1.200	N1= 1.74000	ν1= 28.26
r2= 46.105			
	d2= 4.909	N2= 1.49310	ν2= 83.58
r3= 557.712			
	d3= 0.100		
r4= 41.139			
	d4= 3.518	N3= 1.49310	ν3= 83.58
r5= 95.433			
	d5= 1.000～28.553～40.964		
r6= 28.766			
	d6= 0.800	N4= 1.80420	ν4= 46.50
r7= 8.145			
	d7= 6.254		
r8= -24.683			
	d8= 0.800	N5= 1.80741	ν5= 31.59
r9= 408.759			
	d9= 2.972	N6= 1.84666	ν6= 23.82
r10= -15.616			
	d10= 0.727		
r11= -12.222			
	d11= 0.800	N7= 1.52510	ν7= 56.38
r12*= -72.536			
	d12=24.622～4.490～1.000		
r13= ∞(ST)			
	d13= 0.800		

r14=　11.863
d14= 2.033　N8= 1.78831　ν8= 47.32
r15=　212.313
d15= 5.251
r16=　-66.079
d16= 1.795　N9= 1.48749　ν9= 70.44
r17=　-10.997
d17= 0.800　N10=1.84666　ν10=23.82
r18*=　29.156
d18= 0.100
r19=　12.934
d19= 3.092　N11=1.48749　ν11=70.44
r20*= -19.433
d20= 0.100
r21= -788.619
d21= 4.662　N12=1.79850　ν12=22.60
r22=　-27.115
d22= 1.000～7.000～1.000
r23=　23.066
d23= 0.800　N13=1.85000　ν13=40.04
r24=　11.361
d24= 3.500
r25=　11.740
d25= 1.826　N14=1.79850　ν14=22.60
r26=　14.538
d26= 2.381～2.000～13.578
r27=　∞
d27= 3.000　N15=1.51680　ν15=64.20
r28=　∞

【００４４】
[第１２面(r12)の非球面データ]
ε=1.0000, A4=-0.90791×10^{-4}, A6=-0.27514×10^{-6}, A8=-0.37035×10^{-8}
[第１８面(r18)の非球面データ]
ε=1.0000, A4= 0.28853×10^{-3}, A6= 0.12716×10^{-5}, A8= 0.10778×10^{-7}
[第２０面(r20)の非球面データ]
ε=1.0000

【００４５】
《実施例２》
f=7.5～25.5～50.6, FNO=2.48～3.07～3.60
[曲率半径]　[軸上面間隔]　[屈折率]　[アッベ数]
r1=　62.012
d1=　1.200　N1= 1.79850　ν1= 22.60
r2=　50.059
d2=　3.893　N2= 1.49310　ν2= 83.58
r3=　264.139
d3=　0.100
r4=　57.561
d4=　2.818　N3= 1.49310　ν3= 83.58
r5=　155.066
d5=　1.000～30.739～48.448

r6= 29.965

d6= 0.800 N4= 1.75450 ν4= 51.57

r7= 9.032

d7= 7.570

r8= -52.559

d8= 0.800 N5= 1.75450 ν5= 51.57

r9= 21.530

d9= 4.134 N6= 1.79850 ν6= 22.60

r10= -18.800

d10= 0.486

r11= -15.910

d11= 0.800 N7= 1.84666 ν7= 23.82

r12*=-107.564

d12=25.513～4.405～1.000

r13= ∞(ST)

d13= 0.800

r14= 13.086

d14= 1.832 N8= 1.80750 ν8= 35.43

r15= 84.611

d15= 3.644

r16= 15.627

d16= 2.756 N9= 1.75450 ν9= 51.57

r17= -12.357

d17= 0.800 N10=1.84666 ν10=23.82

r18= 9.111

d18= 0.100

r19= 7.143

d19= 1.343 N11=1.52510 ν11=56.38

r20*= 13.828

d20= 2.118

r21= 31.671

d21= 1.530 N12=1.79850 ν12=22.60

r22= -35.431

d22= 1.000～5.669～4.095

r23= 26.961

d23= 0.800 N13=1.85000 ν13=40.04

r24= 9.331

d24= 2.307

r25= 11.028

d25= 1.289 N14=1.79850 ν14=22.60

r26= 14.503

d26= 2.123～2.989～8.644

r27= -130.604

d27= 1.347 N15=1.79850 ν15=22.60

r28= -33.480

d28= 0.858

r29= ∞

d29= 3.000 N16=1.51680 ν16=64.20

r30= ∞

【００４６】

［第１２面(r12)の非球面データ］
ε=1.0000, A4=-0.44023×10^{-4}, A6=-0.52908×10^{-7}, A8=-0.21921×10^{-8}
［第２０面(r20)の非球面データ］
ε=1.0000, A4= 0.52117×10^{-3}, A6= 0.41505×10^{-5}, A8= 0.98968×10^{-7}

【００４７】
《実施例３》
f=7.4〜23.0〜49.5, FNO=2.22〜2.64〜3.60

［曲率半径］	［軸上面間隔］	［屈折率］	［アッベ数］
r1= 63.356			
	d1= 1.200	N1= 1.79850	ν1= 22.60
r2= 49.435			
	d2= 4.655	N2= 1.49310	ν2= 83.58
r3= 579.022			
	d3= 0.100		
r4= 35.101			
	d4= 4.695	N3= 1.49310	ν3= 83.58
r5= 120.463			
	d5= 1.000〜20.900〜28.705		
r6= 70.488			
	d6= 0.800	N4= 1.78831	ν4= 47.32
r7= 8.526			
	d7= 5.198		
r8= -90.436			
	d8= 0.800	N5= 1.75450	ν5= 51.57
r9= -785.404			
	d9= 2.674	N6= 1.84666	ν6= 23.82
r10= -17.628			
	d10= 0.515		
r11= -14.870			
	d11= 0.800	N7= 1.48749	ν7= 70.44
r12= 45.809			
	d12= 1.366		
r13= -26.330			
	d13= 1.344	N8= 1.84666	ν8= 23.82
r14*= -30.311			
	d14=23.018〜5.870〜1.000		
r15= ∞(ST)			
	d15= 0.800		
r16= 11.633			
	d16= 2.165	N9= 1.80420	ν9= 46.50
r17= 78.024			
	d17= 4.756		
r18= -96.322			
	d18= 1.561	N10=1.75450	ν10=51.57
r19= -14.086			
	d19= 0.800	N11=1.84666	ν11=23.82
r20*= 20.484			
	d20= 0.155		
r21= 10.937			
	d21= 2.506	N12=1.48749	ν12=70.44

r22*= -29.274
d22= 2.186
r23= 90.101
d23= 1.374 N13=1.79850 ν13=22.60
r24= -61.263
d24= 1.000～4.206～1.000
r25= 29.977
d25= 0.800 N14=1.85000 ν14=40.04
r26= 10.683
d26= 3.356
r27= 11.252
d27= 1.235 N15=1.79850 ν15=22.60
r28= 13.786
d28= 1.399～3.217～16.734
r29= 22.159
d29= 1.546 N16=1.79850 ν16=22.60
r30= 89.583
d30= 1.176
r31= ∞
d31= 3.000 N17=1.51680 ν17=64.20
r32= ∞

【００４８】

［第１４面(r14)の非球面データ］
ε=1.0000, A4=-0.55658×10^{-4}, A6=-0.18456×10^{-6}, A8=-0.60664×10^{-8}
［第２０面(r20)の非球面データ］
ε=1.0000, A4= 0.28248×10^{-3}, A6= 0.17454×10^{-5}, A8= 0.32532×10^{-7}
［第２２面(r22)の非球面データ］
ε=1.0000

【００４９】

《実施例４》
f=7.4～35.9～49.6, FNO=2.88～3.04～3.63
［曲率半径］ ［軸上面間隔］ ［屈折率］ ［アッベ数］
r1= 60.590
d1= 1.200 N1= 1.84666 ν1= 23.82
r2= 47.616
d2= 5.549 N2= 1.49310 ν2= 83.58
r3= 603.843
d3= 0.100
r4= 39.319
d4= 4.325 N3= 1.49310 ν3= 83.58
r5= 105.185
d5= 1.000～32.186～36.134
r6= 50.395
d6= 0.800 N4= 1.85000 ν4= 40.04
r7= 8.808
d7= 5.350
r8= -22.935
d8= 0.800 N5= 1.85000 ν5= 40.04
r9= 16.429
d9= 5.107 N6= 1.71736 ν6= 29.50

r10= -17.500
d10= 0.100
r11*= 54.395
d11= 2.000 N7= 1.84506 ν7= 23.66
r12= 1000.000
d12= 1.278
r13= -19.690
d13= 0.800 N8= 1.75450 ν8= 51.57
r14= -77.927
d14=22.063～1.444～1.300
r15= ∞(ST)
d15= 0.800
r16= 12.783
d16= 2.898 N9= 1.85000 ν9= 40.04
r17= 105.738
d17= 3.453
r18*= 37.506
d18= 2.226 N10=1.84506 ν10=23.66
r19= 9.939
d19= 1.104
r20= 12.962
d20= 4.135 N11=1.69680 ν11=55.43
r21= -8.915
d21= 0.800 N12=1.84666 ν12=23.82
r22=26007.802
d22= 1.396
r23= 186.617
d23= 2.183 N13=1.83350 ν13=21.00
r24= -21.147
d24= 1.810～6.450～1.000
r25= 38.703
d25= 0.800 N14=1.85000 ν14=40.04
r26= 13.436
d26= 4.085
r27= 14.114
d27= 1.362 N15=1.83350 ν15=21.00
r28= 18.526
d28= 1.000～5.337～17.559
r29= 16.513
d29= 1.967 N16=1.48749 ν16=70.44
r30= 44.597
d30= 1.479
r31= ∞
d31= 3.000 N17=1.51680 ν17=64.20
r32= ∞

【００５０】

[第１１面(r11)の非球面データ]
ε=1.0000, A4= 0.40063×10^{-4}, A6= 0.39528×10^{-6}, A8=-0.29922×10^{-8}
[第１８面(r18)の非球面データ]
ε=1.0000, A4=-0.11545×10^{-3}, A6=-0.96168×10^{-6}, A8= 0.16989×10^{-7}

【００５１】

《実施例５》

f=8.9～33.7～84.8, FNO=2.43～3.17～3.60

[曲率半径]	[軸上面間隔]	[屈折率]	[アッベ数]
r1= 171.427			
	d1= 1.497	N1= 1.84666	ν1= 23.82
r2= 114.665			
	d2= 6.918	N2= 1.49310	ν2= 83.58
r3= -850.123			
	d3= 0.100		
r4= 96.816			
	d4= 4.523	N3= 1.49310	ν3= 83.58
r5= 348.049			
	d5= 2.486～40.898～95.614		
r6*= 24.483			
	d6= 2.000	N4= 1.75450	ν4= 51.57
r7= 12.754			
	d7= 11.729		
r8= -33.584			
	d8= 0.800	N5= 1.52208	ν5= 65.92
r9= 21.063			
	d9= 4.926	N6= 1.84705	ν6= 25.00
r10= -81.045			
	d10= 0.838		
r11= -40.184			
	d11= 0.800	N7= 1.74495	ν7= 24.47
r12= 99.136			
	d12=41.883～2.565～1.250		
r13= ∞(ST)			
	d13= 1.500		
r14= 12.436			
	d14= 3.485	N8= 1.75450	ν8= 51.57
r15= -172.448			
	d15= 1.166		
r16= 375.028			
	d16= 0.800	N9= 1.71675	ν9= 26.91
r17= 30.185			
	d17= 1.000～1.169～1.244		
r18*= 16.888			
	d18= 1.922	N10=1.84666	ν10=23.82
r19= 11.475			
	d19= 1.988～11.017～23.820		
r20*= 25.613			
	d20= 0.800	N11=1.75000	ν11=25.14
r21= 14.963			
	d21= 0.077		
r22= 15.312			
	d22= 1.202	N12=1.75450	ν12=51.57
r23= 16.980			
	d23= 0.356		

r24=　16.249
　　d24= 6.391　N13=1.49310　ν13=83.58
r25=　-22.015
　　d25= 1.962
r26=　-13.823
　　d26= 3.437　N14=1.84666　ν14=23.82
r27=　-14.151
　　d27= 2.000〜12.427〜6.704
r28*=　20.728
　　d28= 2.834　N15=1.52510　ν15=56.38
r29=　15.822
　　d29= 1.307
r30=　∞
　　d30= 3.000　N16=1.51680　ν16=64.20
r31=　∞

【００５２】

［第６面(r6)の非球面データ］
ε=1.0000, A4= 0.66358×10^{-5}, A6= 0.71481×10^{-9}, A8= 0.49766×10^{-10}
［第１８面(r18)の非球面データ］
ε=1.0000, A4=-0.10218×10^{-3}, A6=-0.12797×10^{-5}, A8= 0.10173×10^{-7},
A10=-0.34395×10^{-9}
［第２０面(r20)の非球面データ］
ε=1.0000, A4=-0.34705×10^{-4}, A6= 0.10595×10^{-6}, A8=-0.43764×10^{-8},
A10= 0.17721×10^{-10}
［第２８面(r28)の非球面データ］
ε=1.0000, A4=-0.59570×10^{-5}, A6=-0.55853×10^{-6}, A8= 0.11878×10^{-7},
A10=-0.14101×10^{-9}

【００５３】

《実施例６》
f=7.1〜53.0〜68.6, FNO=2.55〜3.60〜3.60
［曲率半径］　［軸上面間隔］　［屈折率］　［アッベ数］
r1=　81.309
　　d1=　1.400　N1= 1.84666　ν1= 23.86
r2=　63.920
　　d2=　4.957　N2= 1.49310　ν2= 83.58
r3= -2566.999
　　d3=　0.100
r4=　72.424
　　d4=　2.914　N3= 1.49310　ν3= 83.58
r5=　204.372
　　d5=　0.900〜54.218〜57.909
r6*=-2187.849
　　d6=　1.200　N4= 1.77250　ν4= 49.77
r7*=　14.815
　　d7=　8.614
r8=　-22.207
　　d8=　1.500　N5= 1.84668　ν5= 23.86
r9=　-39.485
　　d9=　0.100
r10=　528.712

d10= 4.283 N6= 1.84666 ν6= 23.82
r11= -27.851
d11= 1.412
r12= -19.591
d12= 1.000 N7= 1.49310 ν7= 83.58
r13= -80.805
d13=40.111～0.619～0.100
r14= ∞(ST)
d14= 1.200
r15*= 20.034
d15= 3.327 N8= 1.77112 ν8= 48.87
r16= 2658.231
d16= 0.100
r17= 24.453
d17= 1.028 N9= 1.61287 ν9= 33.36
r18*= 9.473
d18= 0.432
r19= 12.678
d19= 2.612 N10=1.75450 ν10=51.57
r20= -167.012
d20= 0.537～1.270～1.348
r21= -32.395
d21= 6.981 N11=1.64379 ν11=56.31
r22= -11.929
d22= 0.100
r23*= -13.515
d23= 1.708 N12=1.63456 ν12=31.17
r24*= 24.372
d24= 0.263～19.944～27.790
r25= 19.740
d25= 4.770 N13=1.79850 ν13=22.60
r26= 13.053
d26= 0.100
r27= 13.309
d27= 5.694 N14=1.68636 ν14=54.20
r28= -129.207
d28= 4.148～5.575～2.763
r29= ∞
d29= 3.000 N15=1.51680 ν15=64.20
r32= ∞

【００５４】

［第６面(r6)の非球面データ］
$\varepsilon=1.0000$, A4= 0.29074×10^{-4}, A6= -0.89940×10^{-7}, A8= 0.16625×10^{-9}
［第７面(r7)の非球面データ］
$\varepsilon=1.0000$, A4= 0.44003×10^{-5}, A6= 0.99743×10^{-8}, A8= -0.48301×10^{-9}
［第１５面(r15)の非球面データ］
$\varepsilon=1.0000$, A4= -0.11178×10^{-3}, A6= 0.10605×10^{-5}, A8= -0.21375×10^{-7},
A10= 0.22240×10^{-9}
［第１８面(r18)の非球面データ］
$\varepsilon=1.0000$, A4= -0.24094×10^{-3}, A6= 0.11663×10^{-5}, A8= -0.57504×10^{-7},

A10= 0.66415×10^{-9}

[第２３面(r23)の非球面データ]

ε=1.0000, A4= 0.12224×10^{-3}, A6= -0.66295×10^{-5}, A8= 0.74249×10^{-7}

[第２４面(r24)の非球面データ]

ε=1.0000, A4= 0.29363×10^{-3}, A6= -0.57030×10^{-5}, A8= 0.80185×10^{-7}

【００５５】

《実施例７》

f=7.1〜20.0〜49.0, FNO=2.50〜3.03〜3.66

[曲率半径]	[軸上面間隔]	[屈折率]	[アッベ数]
r1= 111.111			
	d1= 1.400	N1= 1.79850	ν1= 22.60
r2= 85.390			
	d2= 4.303	N2= 1.49310	ν2= 83.58
r3= -1831.972			
	d3= 0.100		
r4= 43.431			
	d4= 4.988	N3= 1.49310	ν3= 83.58
r5= 130.083			
	d5= 0.900〜24.171〜43.681		
r6= 35.035			
	d6= 1.200	N4= 1.75450	ν4= 51.57
r7= 10.040			
	d7= 4.791		
r8= -96.605			
	d8= 1.100	N5= 1.75450	ν5= 51.57
r9= 15.175			
	d9= 1.925		
r10*= 25.398			
	d10= 3.981	N6= 1.84666	ν6= 23.82
r11*= -43.373			
	d11= 1.258		
r12= -15.932			
	d12= 1.000	N7= 1.48749	ν7= 70.44
r13= -134.899			
	d13=20.871〜5.426〜0.600		
r14= ∞(ST)			
	d14= 0.600		
r15= 11.251			
	d15= 2.129	N8= 1.75450	ν8= 51.57
r16= 422.558			
	d16= 4.585		
r17*= -39.509			
	d17= 1.500	N9= 1.70395	ν9= 26.41
r18*= 12.891			
	d18= 0.596		
r19= 12.874			
	d19= 2.614	N10=1.48749	ν10=70.44
r20= -14.240			
	d20= 1.806〜1.837〜3.682		
r21=-8157.937			

d21= 0.800 N11=1.71649 ν11=25.74
r22= 13.228
d22= 0.445
r23= 13.631
d23= 1.919 N12=1.48749 ν12=70.44
r24= 668.856
d24= 3.002〜1.300〜12.240
r25= 31.322
d25= 1.691 N13=1.79850 ν13=22.60
r26= 217.261
d26= 0.500〜9.743〜7.994
r27= 18.461
d27= 4.643 N14=1.79850 ν14=22.60
r28= -11.955
d28= 0.460 N15=1.83724 ν15=30.17
r26= 21.532
d29= 0.900
r30= ∞
d27= 3.000 N16=1.51680 ν16=64.20
r31= ∞

【００５６】

[第１０面(r10)の非球面データ]
ε=1.0000, A4= 0.34767×10^{-4}, A6= 0.63939×10^{-7}, A8=-0.15659×10^{-8}
[第１１面(r11)の非球面データ]
ε=1.0000, A4=-0.11239×10^{-4}, A6=-0.50907×10^{-7}, A8=-0.20881×10^{-8}
[第１７面(r17)の非球面データ]
ε=1.0000, A4=-0.53164×10^{-3}, A6= 0.11706×10^{-4}, A8=-0.13639×10^{-6}
[第１８面(r18)の非球面データ]
ε=1.0000, A4=-0.23930×10^{-3}, A6= 0.14046×10^{-4}, A8=-0.15638×10^{-6}

【００５７】《実施例８》

f=7.5〜45.0〜71.5, FNO=2.17〜2.89〜3.60
[曲率半径] [軸上面間隔] [屈折率] [アッベ数]
r1= 65.664
d1= 1.200 N1= 1.75518 ν1= 29.92
r2= 47.591
d2= 5.244 N2= 1.49310 ν2= 83.58
r3= 217.318
d3= 0.100
r4= 51.066
d4= 4.398 N3= 1.49310 ν3= 83.58
r5= 185.539
d5= 1.000〜45.300〜49.091
r6= 45.239
d6= 0.800 N4= 1.75450 ν4= 51.57
r7= 10.516
d7= 7.570
r8= -40.143
d8= 0.800 N5= 1.80223 ν5= 44.75
r9= 23.630
d9= 5.046 N6= 1.79123 ν6= 22.82

r10= -18.887
d10= 0.656
r11= -15.690
d11= 0.800 N7= 1.84666 ν7= 23.82
r12*= -43.100
d12=35.757～5.453～1.000
r13= ∞(ST)
d13= 0.800
r14= 13.866
d14= 2.194 N8= 1.78923 ν8= 46.34
r15= 74.387
d15= 5.348
r16= 13.726
d16= 3.113 N9= 1.73284 ν9= 52.33
r17= -13.373
d17= 0.800 N10=1.84758 ν10=26.81
r18= 8.964
d18= 0.100
r19= 7.206
d19= 1.439 N11=1.52510 ν11=56.38
r20*= 14.351
d20= 2.601
r21= 21.969
d21= 1.379 N12=1.79850 ν12=22.60
r22=-1723.989
d22= 1.000～3.838～2.749
r23= 342.635
d23= 0.800 N13=1.66384 ν13=35.98
r24= 8.966
d24= 3.000
r25= 24.255
d25= 1.566 N14=1.79850 ν14=22.60
r26*= 120.635
d26= 1.000～5.947～14.698
r27= 25.459
d27= 1.667 N15=1.79850 ν15=22.60
r28= 884.189
d28= 1.019
r29= ∞
d29= 3.000 N16=1.51680 ν16=64.20
r30= ∞

【００５８】

[第１２面(r12)の非球面データ]
$\varepsilon=1.0000, A4=-0.28880\times10^{-4}, A6=-0.39221\times10^{-7}, A8=-0.58769\times10^{-9}$
[第２０面(r20)の非球面データ]
$\varepsilon=1.0000, A4=0.44180\times10^{-3}, A6=0.35794\times10^{-5}, A8=0.93325\times10^{-7}$
[第２６面(r26)の非球面データ]
$\varepsilon=1.0000, A4=-0.73523\times10^{-4}, A6=-0.60792\times10^{-6}, A8=-0.59550\times10^{-8}$

【００５９】

《実施例９》

f=7.5～54.0～86.0, FNO=2.10～2.84～3.60

[曲率半径]	[軸上面間隔]	[屈折率]	[アッベ数]
r1= 90.273			
	d1= 1.200	N1= 1.83304	ν1= 41.53
r2= 50.609			
	d2= 6.584	N2= 1.49310	ν2= 83.58
r3= 491.903			
	d3= 0.100		
r4= 50.212			
	d4= 5.970	N3= 1.49310	ν3= 83.58
r5= 293.841			
	d5= 1.000～56.319～60.499		
r6= 53.739			
	d6= 0.800	N4= 1.75450	ν4= 51.57
r7= 11.112			
	d7= 7.570		
r8= -105.475			
	d8= 0.800	N5= 1.76442	ν5= 49.91
r9= 16.958			
	d9= 6.473	N6= 1.77039	ν6= 23.51
r10= -22.262			
	d10= 0.563		
r11= -19.229			
	d11= 0.800	N7= 1.84666	ν7= 23.82
r12*=-140.106			
	d12=34.166～4.250～1.000		
r13= ∞(ST)			
	d13= 0.800		
r14= 14.098			
	d14= 2.180	N8= 1.83255	ν8= 41.58
r15= 75.309			
	d15= 4.215		
r16= 13.256			
	d16= 3.141	N9= 1.71070	ν9= 53.17
r17= -15.268			
	d17= 0.800	N10=1.80992	ν10=25.83
r18= 7.879			
	d18= 0.274		
r19= 7.000			
	d19= 1.461	N11=1.52510	ν11=56.38
r20*= 13.820			
	d20= 3.133		
r21= 21.375			
	d21= 1.301	N12=1.79850	ν12=22.60
r22= 2254.283			
	d22= 1.000～3.613～1.086		
r23= 2109.616			
	d23= 0.800	N13=1.64794	ν13=36.75
r24= 9.838			
	d24= 2.907		

r25= 21.069

d25= 1.316 N14=1.79850 ν14=22.60

r26*= 59.731

d26= 1.000〜6.745〜18.339

r27= 21.610

d27= 1.710 N15=1.84666 ν15=23.82

r28= 97.515

d28= 1.154

r29= ∞

d31= 3.000 N16=1.51680 ν16=64.20

r30= ∞

【００６０】

[第１２面(r12)の非球面データ]

ε=1.0000, A4=−0.26006×10^{-4} , A6=−0.12948×10^{-7} , A8=−0.69799×10^{-9}

[第２０面(r20)の非球面データ]

ε=1.0000, A4= 0.39398×10^{-3} , A6= 0.33896×10^{-5} , A8= 0.11071×10^{-6}

[第２６面(r26)の非球面データ]

ε=1.0000, A4=−0.53134×10^{-4} , A6=−0.59377×10^{-6} , A8= 0.30506×10^{-8}

【００６１】 ＊ ＊【表１】

《フォーカスデータ》

フォーカス群：第４レンズ群(Gr4)				
撮影距離(物点〜像面)：D＝0.5(m)				
	フォーカス群の移動量			フォーカス群の移動方向
	W	M	T	
実施例１	0.29	3.717	5.181	像面側
実施例２	0.144	1.448	3.372	像面側
実施例３	0.172	1.360	4.638	像面側
実施例４	0.234	3.393	3.349	像面側
実施例５	0.264	2.549	9.552	物体側
実施例６	0.163	5.338	7.961	物体側
実施例７	0.314	1.929	8.601	像面側
実施例８	0.133	2.754	4.258	像面側
実施例９	0.155	4.251	5.783	像面側

【００６２】 【表２】

《条件式対応値》

	条件式(1)	条件式(2)	条件式(3)	条件式(4)
	f1／fT	|f4／fT|	D_{34W}/D_{34T}	β_{W4}
実施例１	1.65	0.95	1.00	1.20
実施例２	1.90	0.59	0.26	1.36
実施例３	1.30	0.60	1.00	1.34
実施例４	1.48	0.86	1.81	1.35
実施例５	1.93	0.60	0.80	1.63
実施例６	1.54	0.36	0.40	2.36
実施例７	1.27	0.79	0.37	1.40
実施例８	1.30	0.35	0.36	1.58
実施例９	1.21	0.32	0.92	1.52

【００６３】

【発明の効果】以上説明したように本発明によれば、コンパクト性で正・負・正・正タイプを超えるパフォーマンスを持つタイプを実現することができ、特に、変倍比が7倍～10倍程度、Ｆナンバーが2.5～4程度で、最先端の小さな画素ピッチの撮像素子用の光学系としても使用できる高い性能を持ち、かつ、コンパクト性に優れた高変倍ズームレンズ系を有する撮像レンズ装置を実現することができる。そして本発明を、デジタルカメラ；ビデオカメラ；デジタルビデオユニット，パーソナルコンピュータ，モバイルコンピュータ，携帯電話，情報携帯端末(ＰＤＡ)等に内蔵又は外付けされるカメラに適用すれば、これらの機器のコンパクト化，高変倍化及び高性能化に寄与することができる。

【図面の簡単な説明】

【図１】第１の実施の形態(実施例１)のレンズ構成図。

【図２】第２の実施の形態(実施例２)のレンズ構成図。

【図３】第３の実施の形態(実施例３)のレンズ構成図。

【図４】第４の実施の形態(実施例４)のレンズ構成図。

【図５】第５の実施の形態(実施例５)のレンズ構成図。

【図６】第６の実施の形態(実施例６)のレンズ構成図。

【図７】第７の実施の形態(実施例７)のレンズ構成図。

【図８】第８の実施の形態(実施例８)のレンズ構成図。

【図９】第９の実施の形態(実施例９)のレンズ構成図。

【図１０】実施例１の無限遠撮影状態での収差図。

【図１１】実施例２の無限遠撮影状態での収差図。

【図１２】実施例３の無限遠撮影状態での収差図。

【図１３】実施例４の無限遠撮影状態での収差図。

【図１４】実施例５の無限遠撮影状態での収差図。

【図１５】実施例６の無限遠撮影状態での収差図。

【図１６】実施例７の無限遠撮影状態での収差図。

【図１７】実施例８の無限遠撮影状態での収差図。

【図１８】実施例９の無限遠撮影状態での収差図。

【図１９】実施例１の近接撮影状態(D=0.5m)での収差図。

【図２０】実施例２の近接撮影状態(D=0.5m)での収差図。

【図２１】実施例３の近接撮影状態(D=0.5m)での収差図。

【図２２】実施例４の近接撮影状態(D=0.5m)での収差図。

【図２３】実施例５の近接撮影状態(D=0.5m)での収差図。

【図２４】実施例８の近接撮影状態(D=0.5m)での収差図。

【図２５】実施例９の近接撮影状態(D=0.5m)での収差図。

【図２６】本発明に係る撮像レンズ装置の概略光学構成を示す模式図。

【符号の説明】

TL　…撮影レンズ系(ズームレンズ系)

SR　…撮像素子

Gr1　…第１レンズ群

Gr2　…第２レンズ群

Gr3　…第３レンズ群

Gr4　…第４レンズ群

Gr5　…第５レンズ群

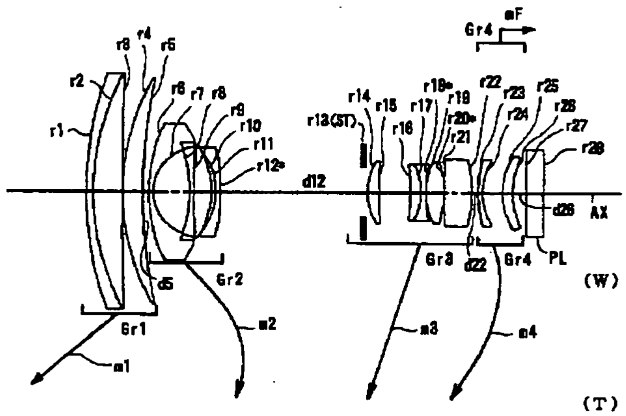
Gr6　…第６レンズ群

PL　…ガラス平板(平行平面板)

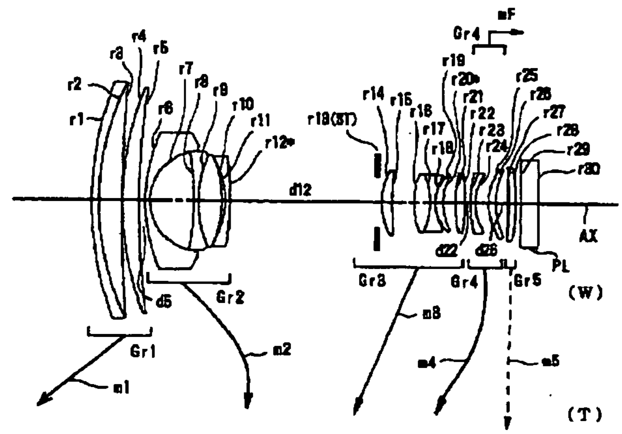
ST　…絞り

AX　…光軸

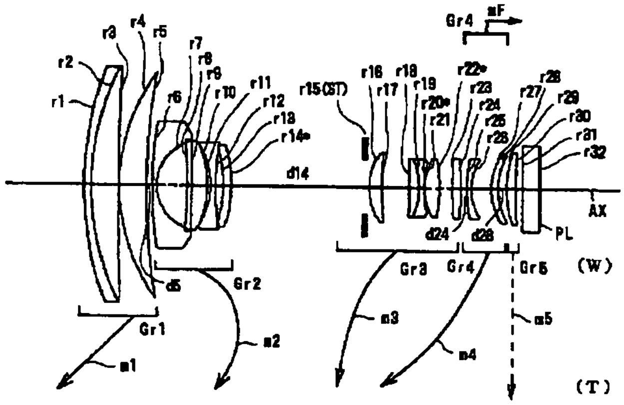
【図１】



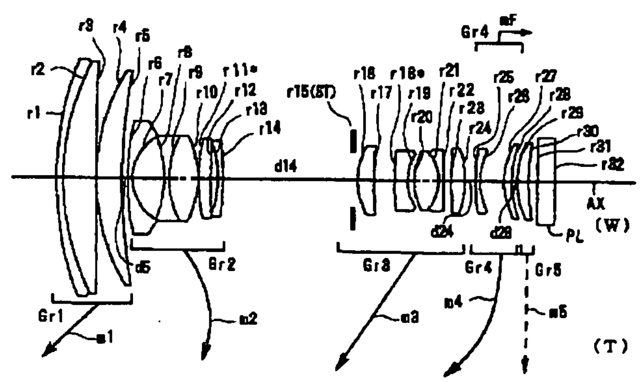
【図２】



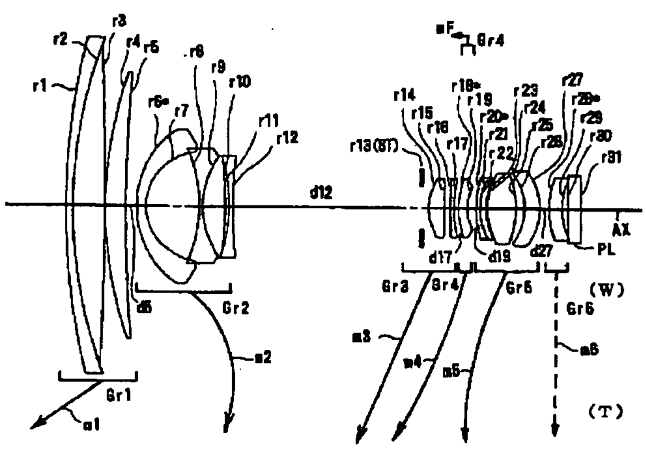
【図３】



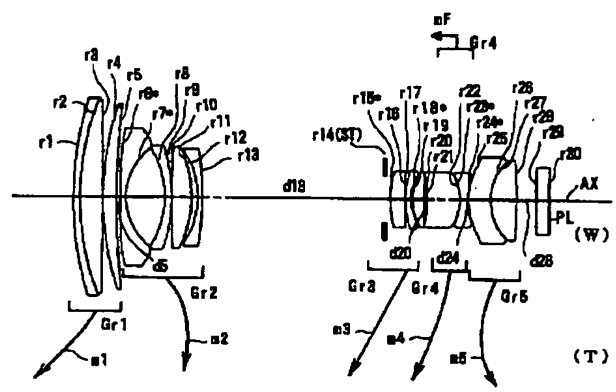
【図４】



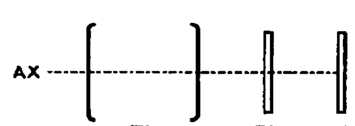
【図５】



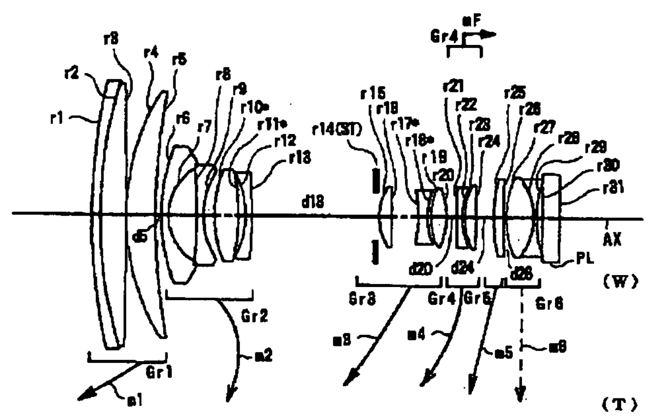
【図６】



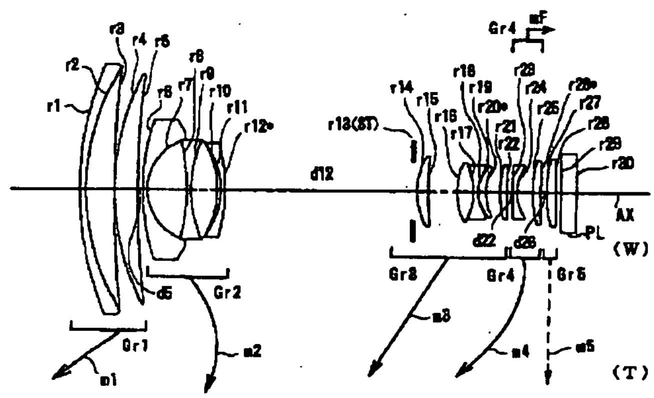
【図２６】



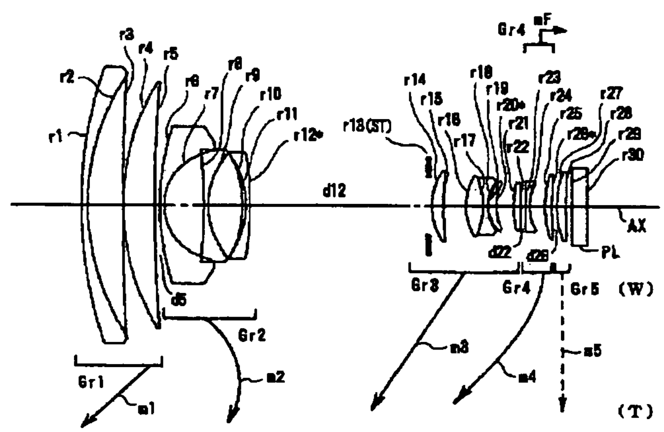
【図７】



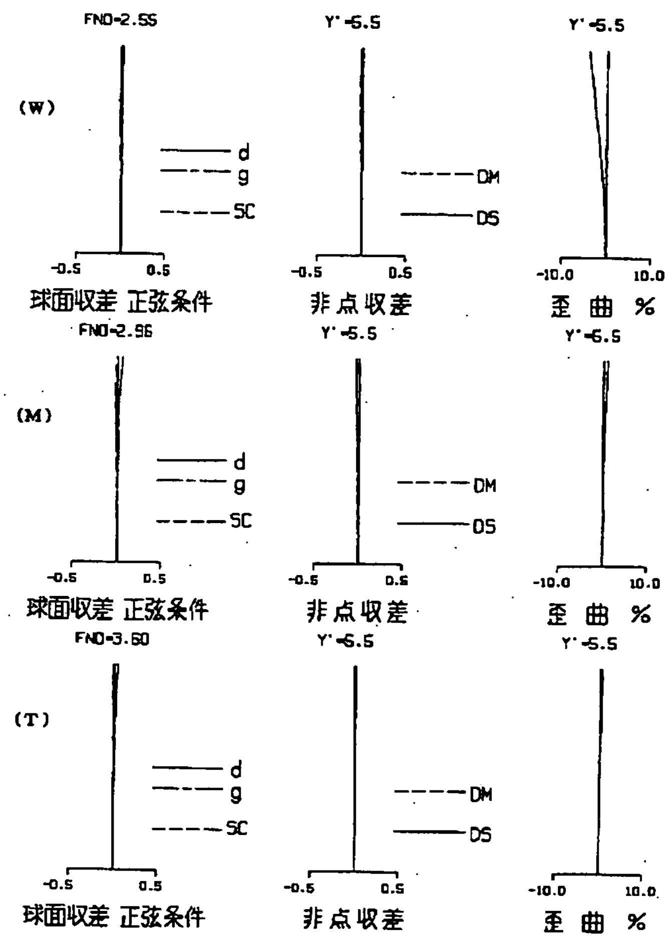
【図８】



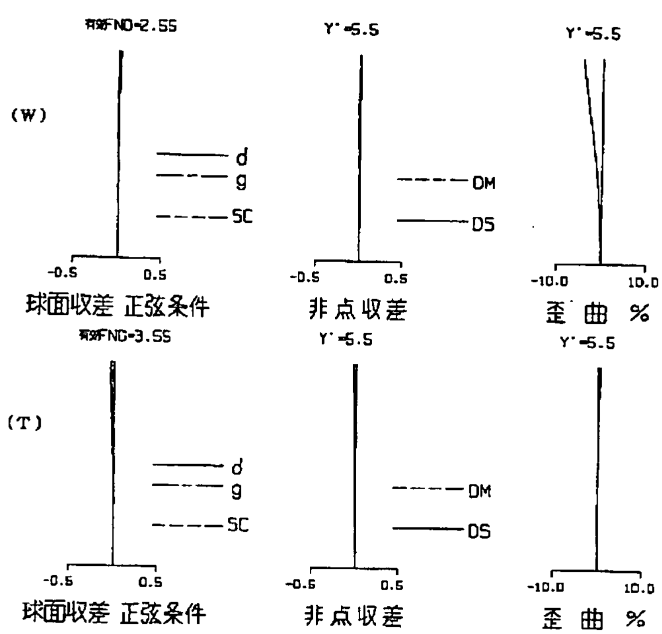
【図９】



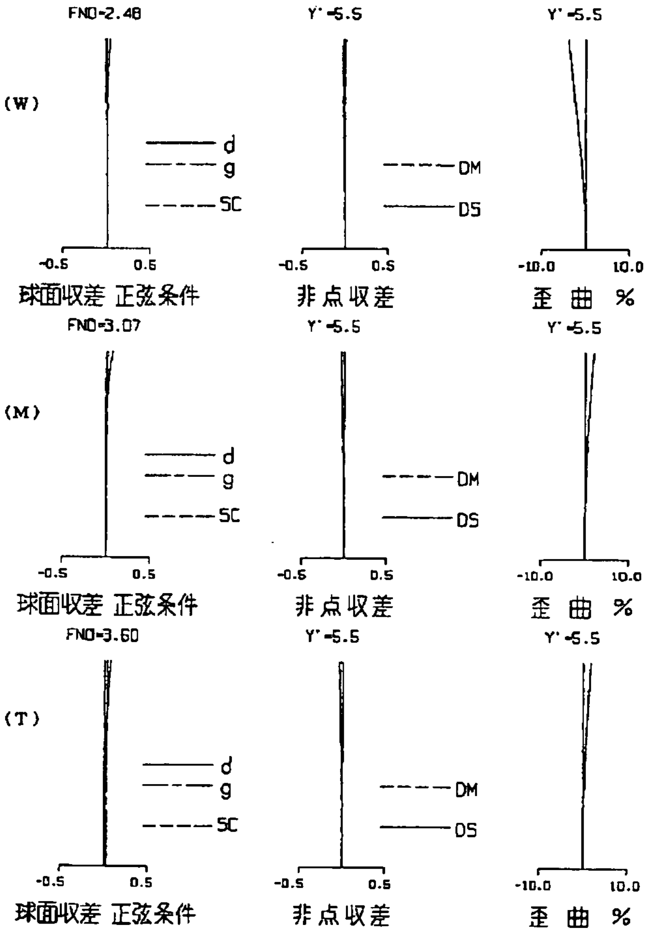
【図１０】



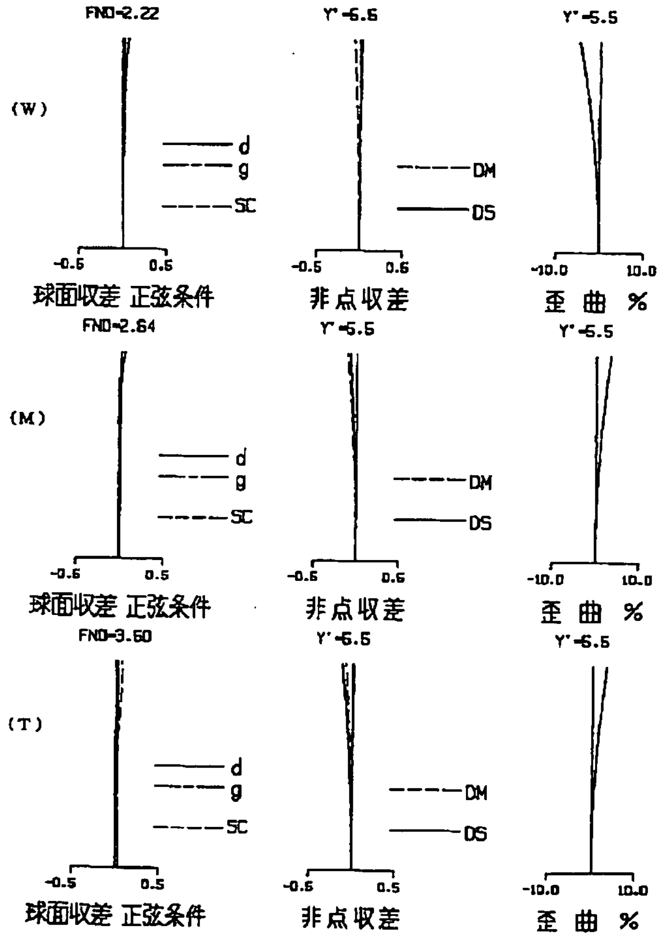
【図１９】



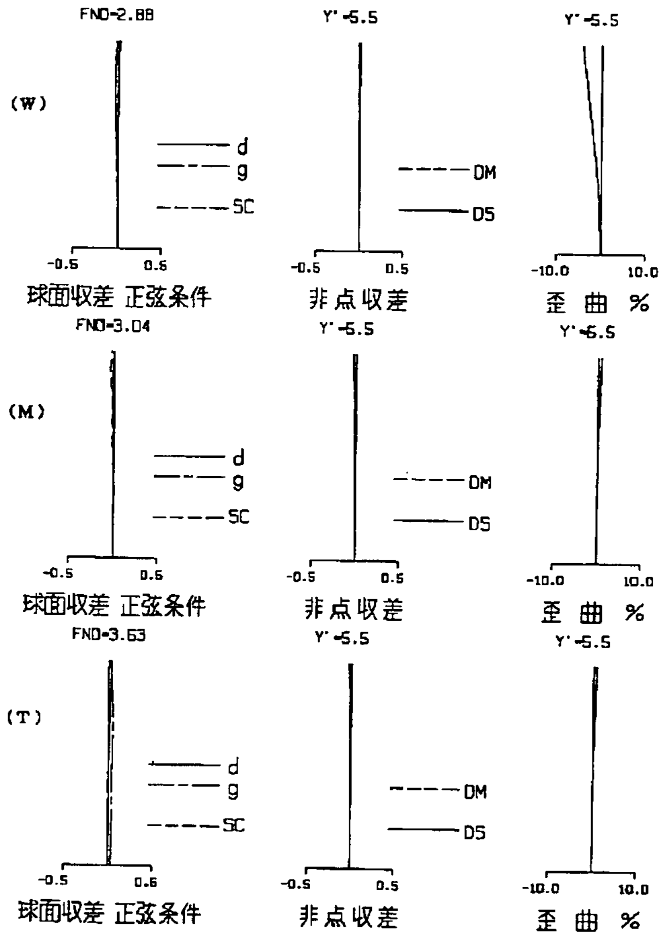
【図１１】


FNO=2.48
Y'=5.5
Y'=5.5
(W)
d
g
SC
DM
DS
-0.5
0.5
-10.0
10.0
球面収差 正弦条件
非点収差
歪 曲 %
FNO=3.07
(M)
FNO=3.60
(T)

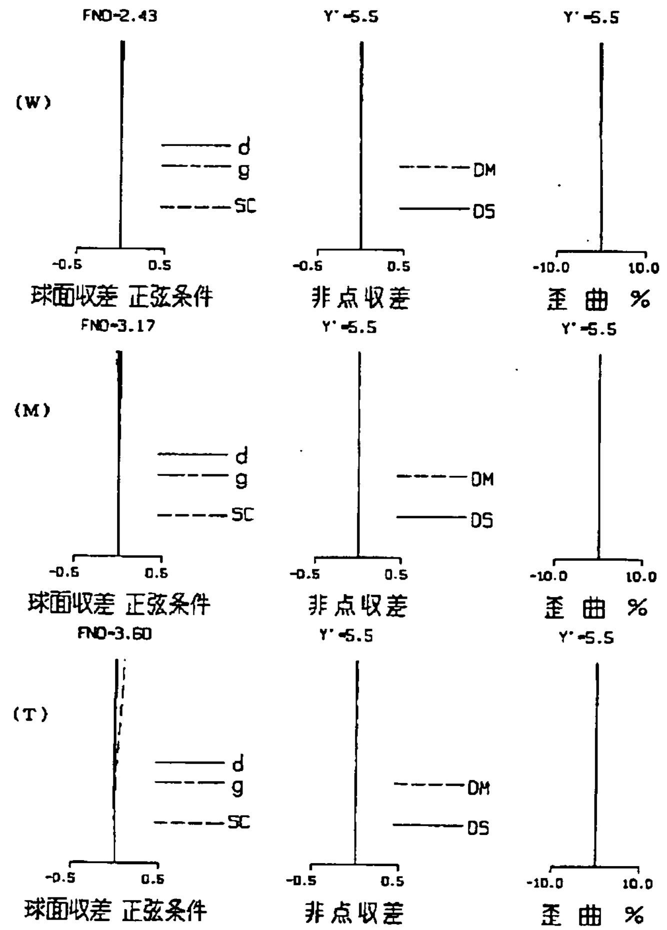
【図１２】


FNO=2.22
Y'=5.5
Y'=5.5
(W)
d
g
SC
DM
DS
-0.5
0.5
-10.0
10.0
球面収差 正弦条件
非点収差
歪 曲 %
FNO=2.64
(M)
FNO=3.60
(T)

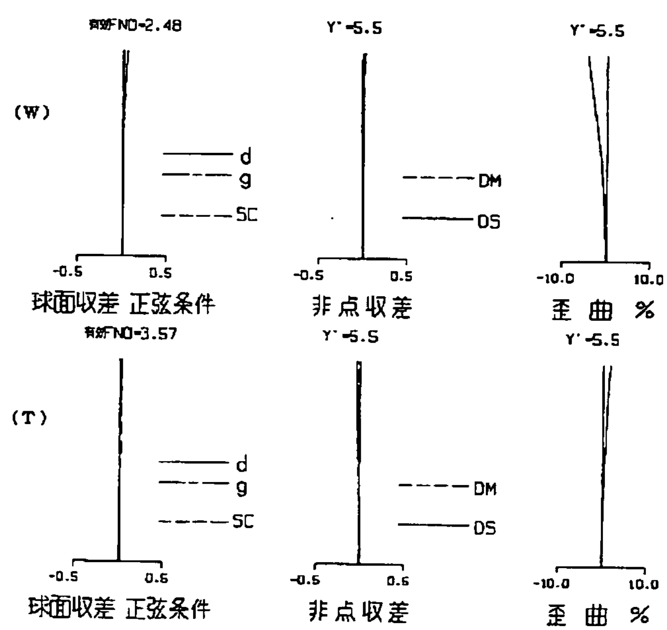
【図１３】


(W)
FNO=2.88
Y'=5.5
Y'=5.5
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪曲 %
(M)
FNO=3.04
Y'=5.5
Y'=5.5
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪曲 %
(T)
FNO=3.63
Y'=5.5
Y'=5.5
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪曲 %

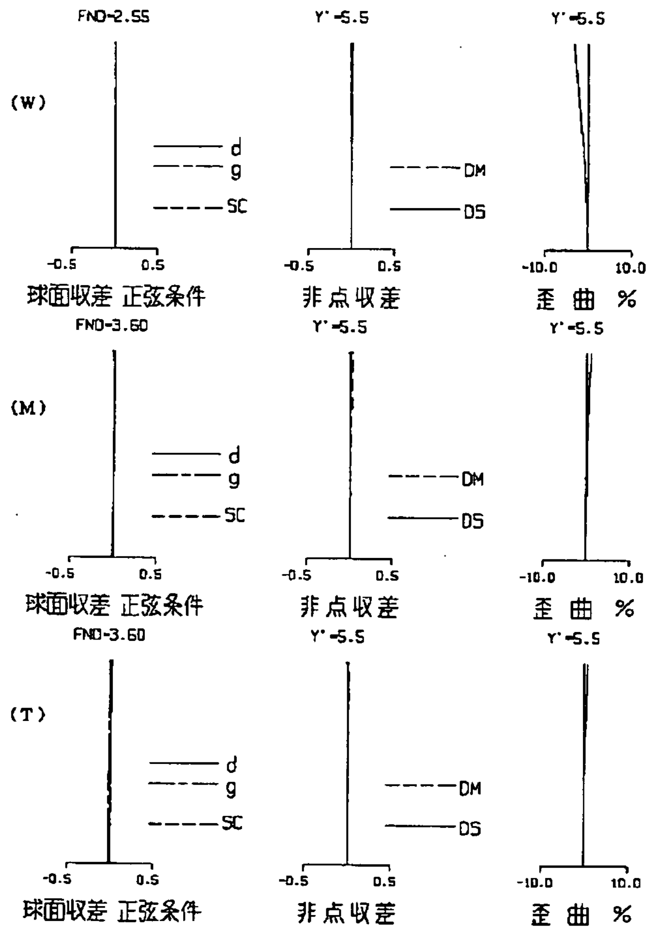
【図１４】


(W)
FNO=2.43
Y'=5.5
Y'=5.5
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪曲 %
(M)
FNO=3.17
Y'=5.5
Y'=5.5
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪曲 %
(T)
FNO=3.60
Y'=5.5
Y'=5.5
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪曲 %

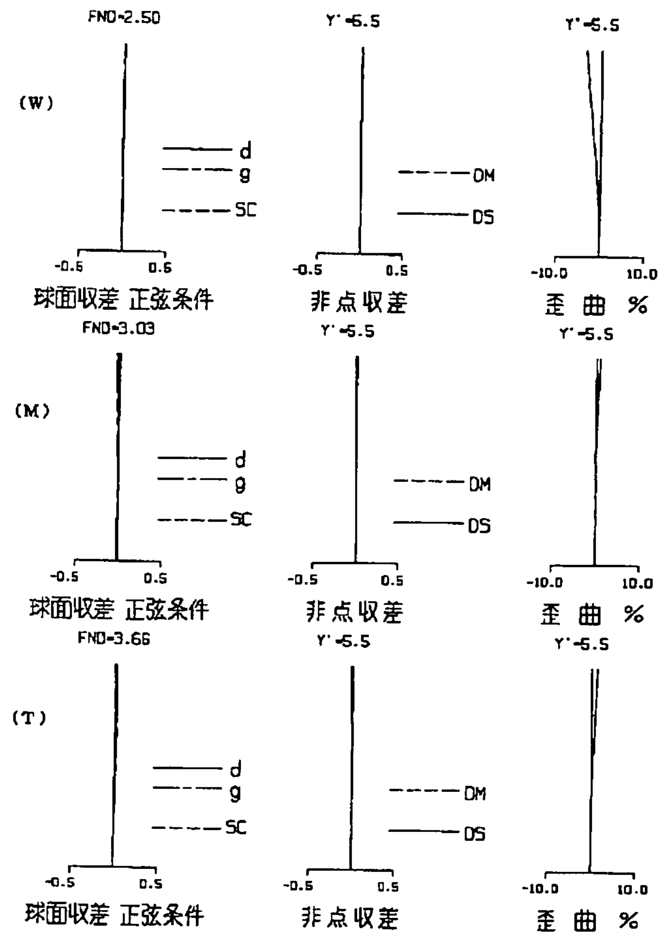
【図２０】


(W)
有効FNO=2.48
Y'=5.5
Y'=5.5
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪曲 %
(T)
有効FNO=3.57
Y'=5.5
Y'=5.5
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪曲 %

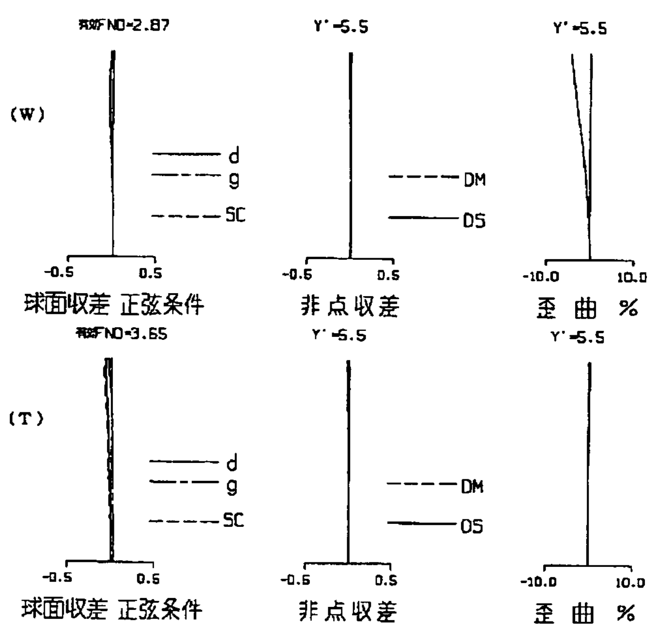
【図１５】


FNO=2.55
Y'=5.5
Y'=5.5
(W)
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪 曲 %
FNO=3.60
(M)
FNO=3.60
(T)

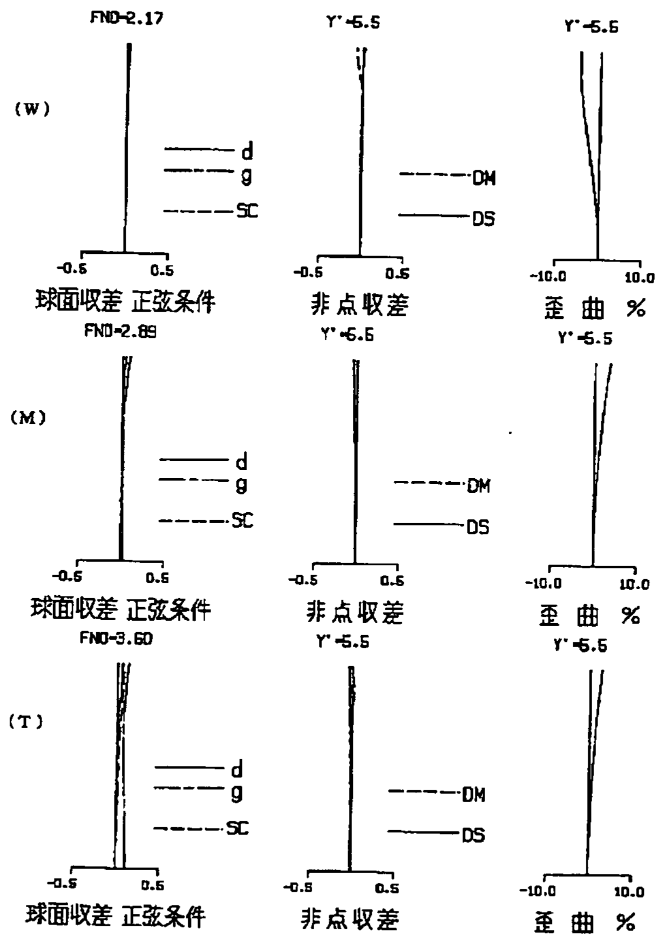
【図１６】


FNO=2.50
Y'=5.5
Y'=5.5
(W)
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪 曲 %
FNO=3.03
(M)
FNO=3.66
(T)

【図２２】

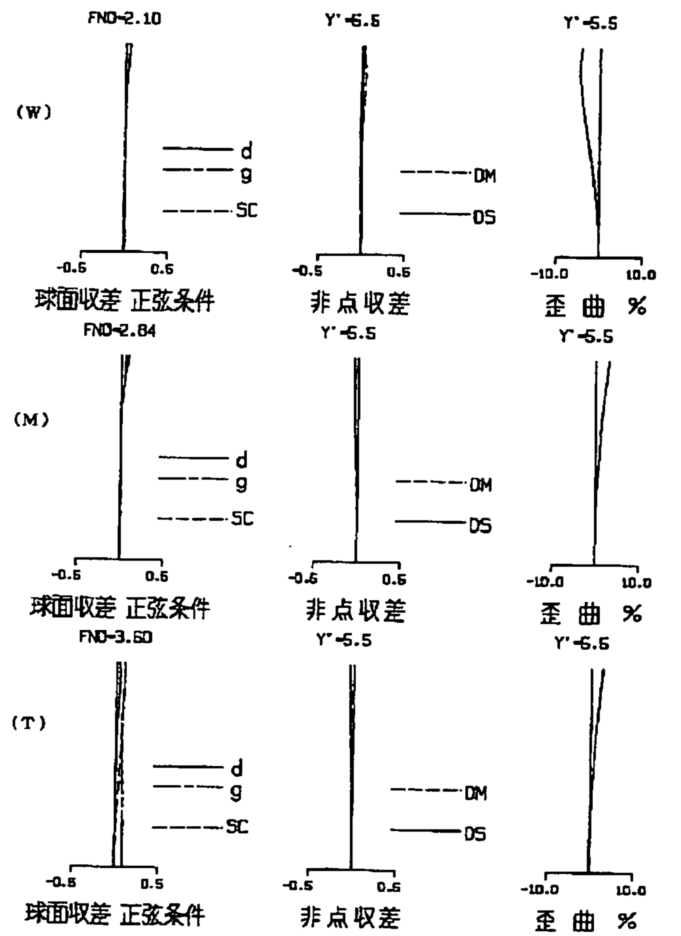

FNO=2.87
Y'=5.5
Y'=5.5
(W)
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪 曲 %
FNO=3.65
(T)

【図１７】



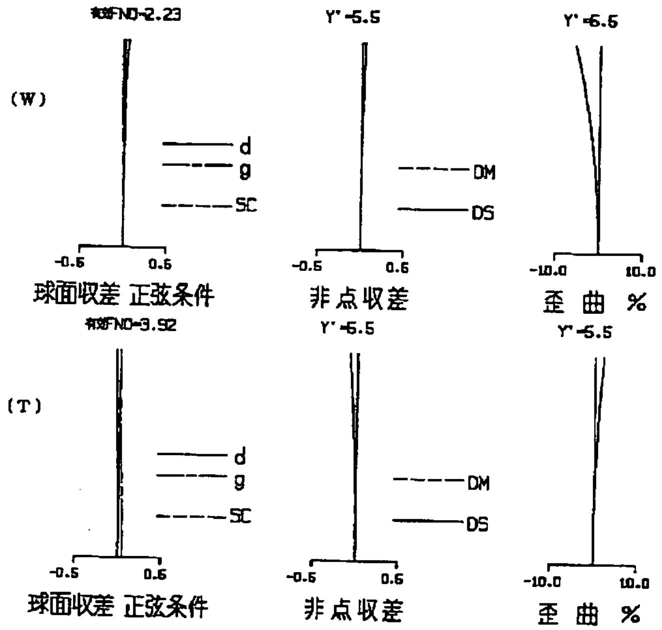
FNO=2.17
Y'=5.5
Y'=5.5
(W)
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪 曲 %
FNO=2.89
Y'=5.5
Y'=5.5
(M)
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪 曲 %
FNO=3.60
Y'=5.5
Y'=5.5
(T)
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪 曲 %

【図１８】

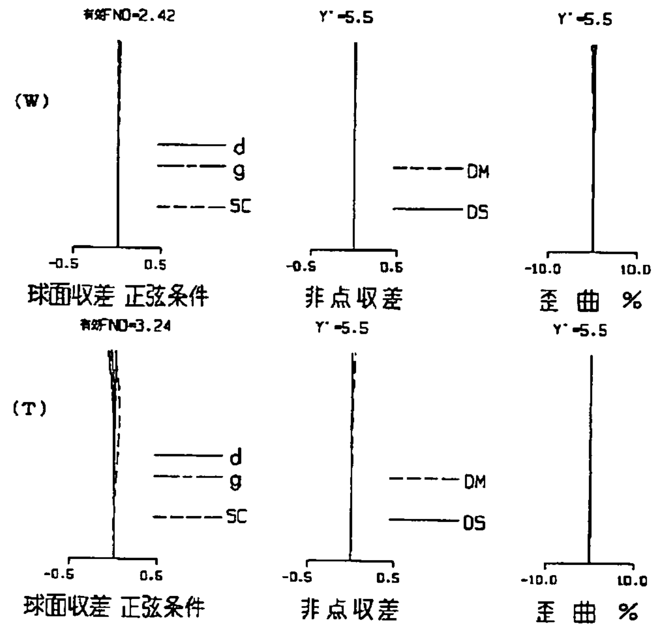


FNO=2.10
Y'=5.5
Y'=5.5
(W)
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪 曲 %
FNO=2.84
Y'=5.5
Y'=5.5
(M)
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪 曲 %
FNO=3.60
Y'=5.5
Y'=5.5
(T)
d
g
SC
DM
DS
-0.5 0.5
-0.5 0.5
-10.0 10.0
球面収差 正弦条件
非点収差
歪 曲 %

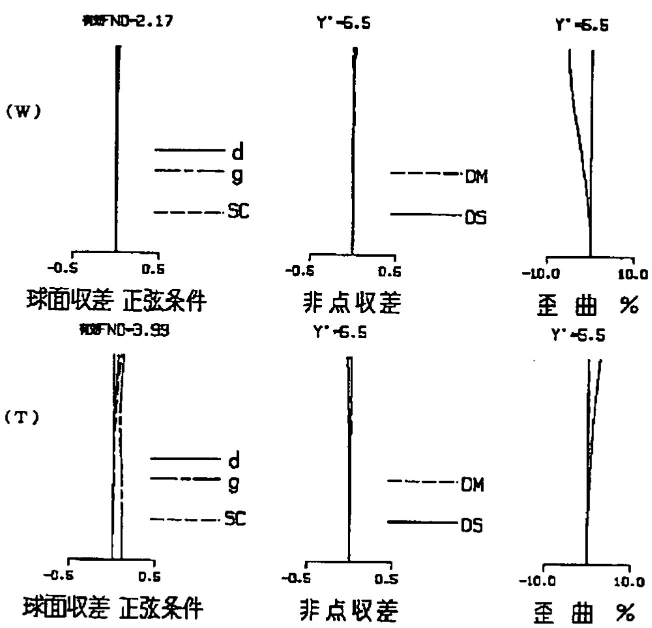
【図２１】



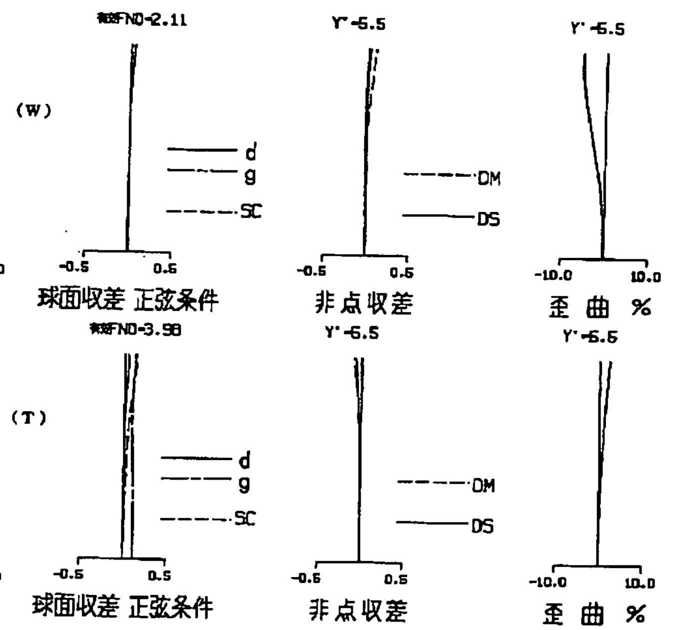
【図２３】



【図２４】



【図２５】



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QA41 QA42 QA45 QA46 RA05
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SA27 SA29 SA33 SA43 SA47
SA49 SA53 SA55 SA57 SA62
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